Technical training.
Product information.

I01 Heating and A/C Systems

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BMW Group University
Technical Training
ST1403a 5/1/2014

BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left-hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as a result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

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BV-72/Technical Training

I01 Heating and A/C Systems

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1. Objectives

This training material provides an overview and information on the heating and air-conditioning system installed in the BMW I01, variants, new components, operating fluids, as well as their special features and functions.

With this reference manual trained workshop technicians are able to identify vehicle configurations and check corresponding performance features of the systems by troubleshooting and diagnosis.

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2. Models

2.1. BMW I01

- I01 version as a pure Battery Electric Vehicle (BEV)
- I01 version with range extender (REX)

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3. Introduction

Interior air temperature control and energy consumption

The different components and subassemblies in this training reference manual are explained, the newly developed parts are shown and their functions are explained.

Automatic climate control IHKA is used for the heating and air-conditioning system in the I01.

- Automatic climate control IHKA as standard equipment on the I01 with REX
- Automatic climate control IHKA as standard equipment, with heat pump with BEV.

In I01 vehicles with range extender a heat pump 4T9, is not offered for weight saving reasons.

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4. First Use in BMW i

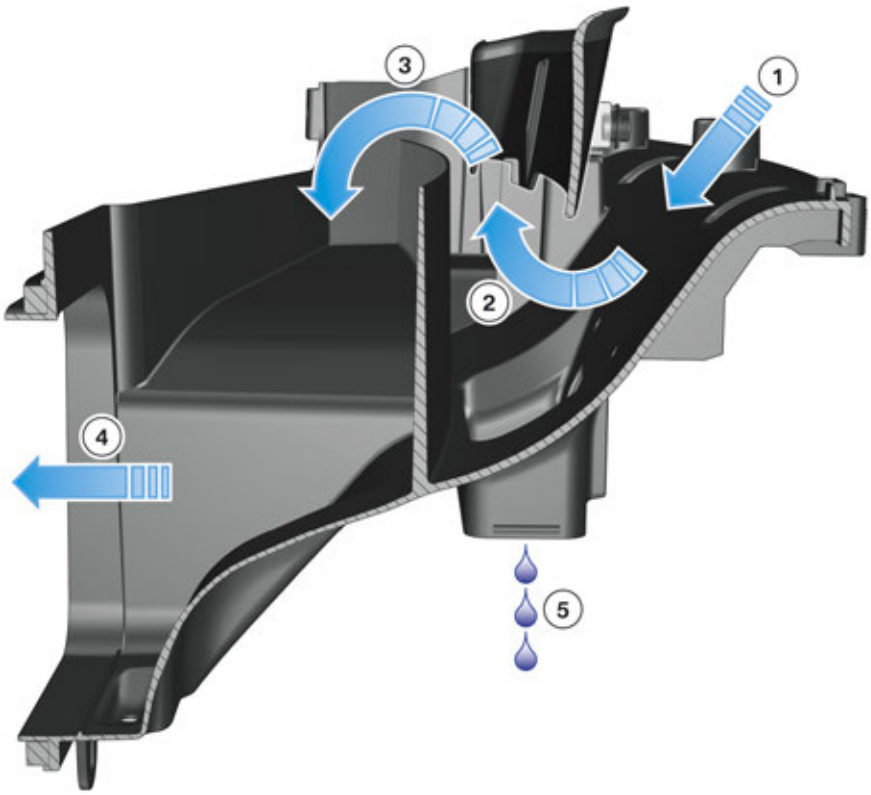
4.1. Prioritized air recirculation function

In the BMW I01 for the first time the air recirculation function is prioritized in order to keep the energy consumption as low as possible when heating and cooling the air passenger compartment.

This means that a comfortable interior temperature for the occupants is maintained using less energy. Constant control of the fresh air temperature is not required or can be reduced.

4.2. Intake plenum and water separation

The housing for the intake plenum is attached at the bulkhead for the passenger compartment. The following graphics show the flow which the fresh air takes to the passenger compartment and how the water of the fresh air drawn in during rainfall is separated.

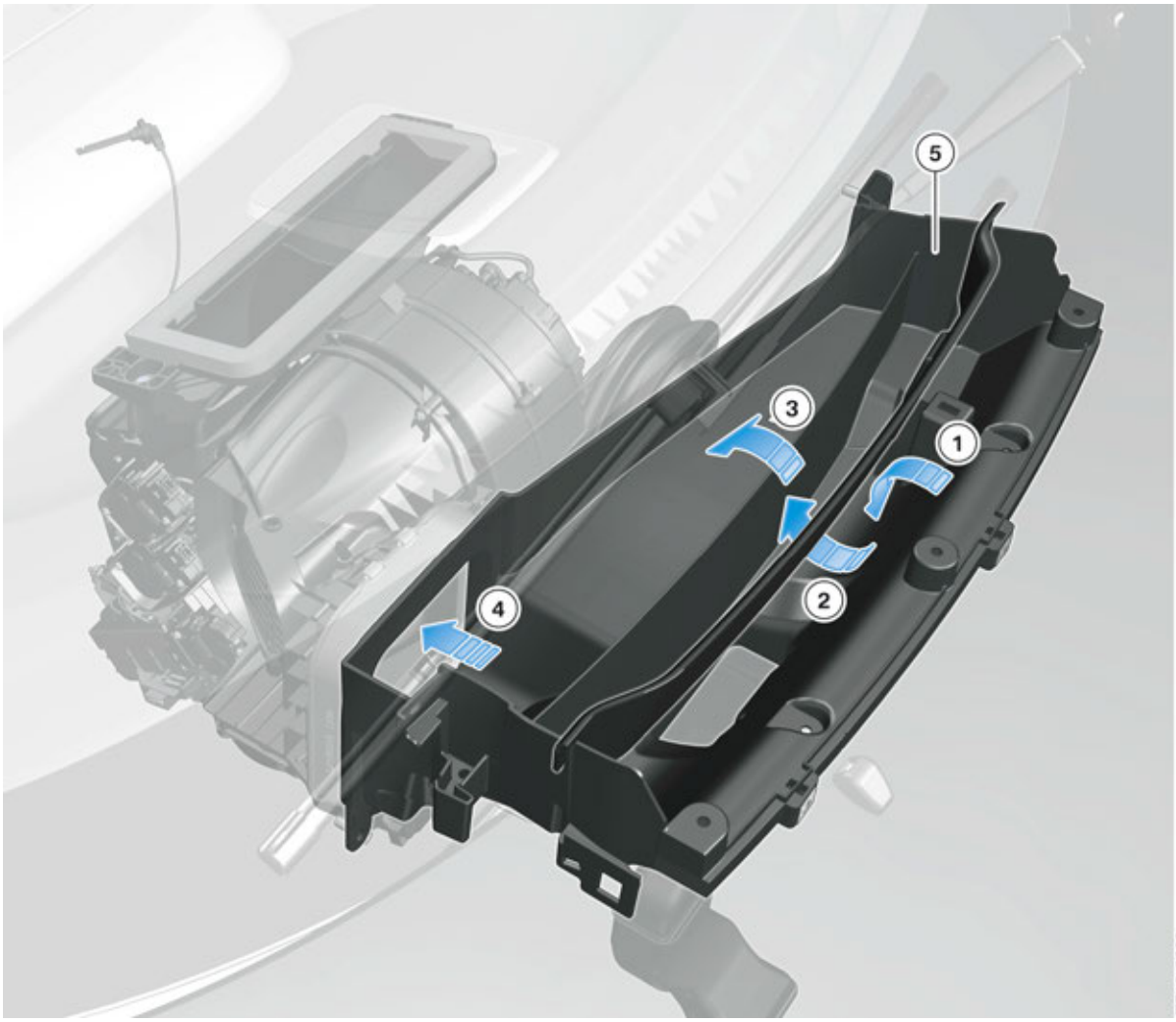


Side view of the intake plenum with schematic diagram of the water discharge

Index	Explanation
1	Fresh air inlet
2	1st redirection of fresh air
3	2nd redirection of fresh air
4	Fresh air, passing through bulkhead
5	Discharge of intake water

I01 Heating and A/C Systems

4. First Use in BMW i



Top view of intake plenum of fresh air

Index	Explanation
1	Fresh air inlet
2	1st redirection of fresh air
3	2nd redirection of fresh air
4	Fresh air, passing through bulkhead
5	Housing of intake plenum

4.3. Sealing ring connection of refrigerant lines

The newly developed connection for the refrigerant line, is an axial sealing ring seat with a flat design, the sealing ring or EPDM, is pressed onto a smooth surface on the opposite side with the surface of a guide ring. Excellent sealing and precise fit are guaranteed with a guide pin and a larger sealing surface.

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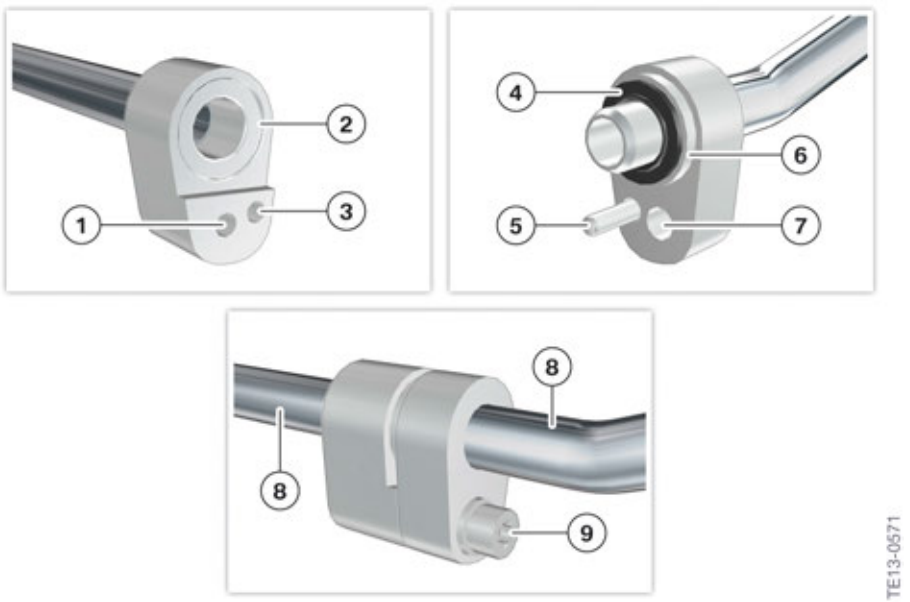
4. First Use in BMW i

During disassembly ensure that no sharp-edged tools are used to separate the connection. The sealing surfaces can be damaged very easily and the replacement of a line may be very costly and time-consuming depending on the section. For proper installation new, dry and clean sealing rings must be used.



New refrigerant connection "seal ring"

Index	Explanation
1	Threaded hole for screw connection
2	Sealing surface
3	Fixture for guide pin
4	Sealing ring
5	Guide pin
6	Guide ring area
7	Hole for screw connection
8	Refrigerant line
9	Screw

4.4. Refrigerant R134a

The I01 vehicles continue to use R134a refrigerant.

The properties of R134a are listed in the table below.

Values	R134a
Boiling point at 1013 hPa	-26 °C
Steam pressure (25 °C)	6.56 bar
Steam pressure (80 °C)	25.97 bar
Vapor density	32.4 kg/m3
Auto-ignition temperature for air/refrigerant mix	>750 °C Combustible only at increased pressure
Flash point	Not inflammable
Dangerous products of decomposition	hydrogen halide, carbon dioxide, carbon monoxide, hydrofluorocarbons and carbonyl-halogenides
Perception	colorless and almost odorless gas
Vehicle properties	Black screw caps on the filling valves

To guarantee occupational safety, it is necessary to wear suitable personal protective equipment based on a risk assessment such as long-sleeve work attire, leather gloves and goggles.

In order to avoid an ignitable atmosphere care must be taken to ensure there is always sufficient ventilation.

4.5. Refrigerant oil

The new refrigerant oil designed for the EKK must satisfy special requirements. Due to the EKK it must have a higher isolation resistance and thus have an inferior electrical conductivity than a standard refrigerant oil. It is approved for refrigerant circuits with R1234yf (not for USA) and R134a (USA) refrigerant, in which an EKK is used.

The designation for the refrigerant oil to be used is "**Sanden SP-A2**".

The new refrigerant oil cannot be mixed with the R134a refrigerant oil which has been used up to now.

BMW i service workshops in markets which supply the I12 with the refrigerant R134a and do not use a separate A/C service station, have the option to introduce the refrigerant oil by means of an injection into the refrigerant circuit. This prevents contamination of the A/C service station. Information on the precise procedure and the necessary special tool can be found in the current repair instructions.

Too much refrigerant oil in the refrigerant circuit can cause the system to switch off. Too little oil may cause damage to the mechanical components of the heating and air-conditioning system.

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4. First Use in BMW i

4.6. Heating circuit for I01 with range extender

The passenger compartment is heated using electric heating by a heater circuit filled with coolant. The electric heating is supplied with energy via the high-voltage system.

Cooling circuit for electric heating

The coolant is drawn in from the expansion tank by the electric coolant pump and pumped to the electric heating. In the electric heating the coolant is heated to the desired customer temperature and conveyed further to the heat exchanger in the passenger compartment. The heat exchanger installed in the heating and air-conditioning unit conveys the heat from the flowing coolant to the air flowing through. Then the coolant flows back to the expansion tank, whereby the cooling circuit closes.

Note: Use special "Coolant concentrate i3".

Heating for the passenger compartment in I01 with range extender

Index	Explanation
1	Heat exchanger in the passenger compartment
2	Electric heating
3	Electric coolant pump (12 V)
4	Coolant expansion tank

4.7. Heating circuit with heat pump (only on BEV vehicles).

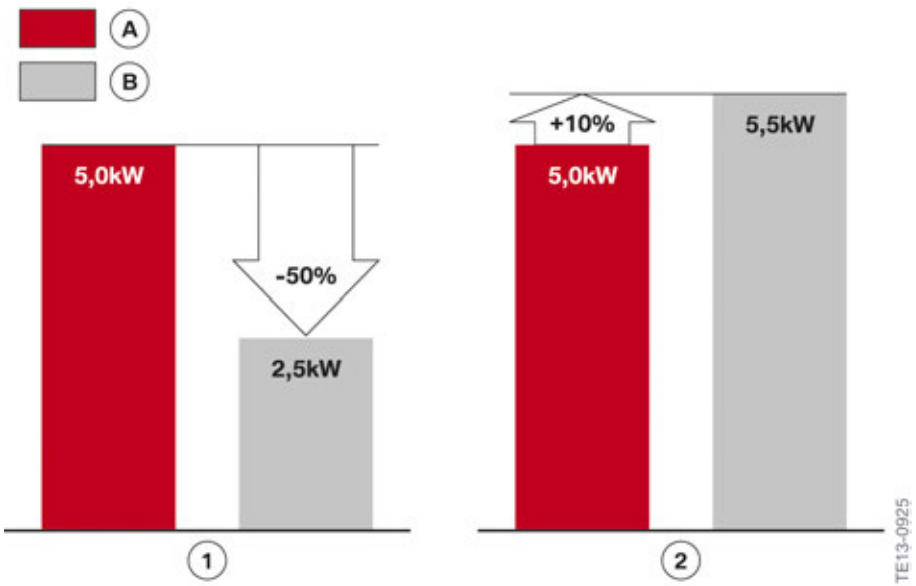
The heat pump heat exchanger is installed in series between the coolant pump and electric heater. The energy consumption of the electric heating is reduced effectively by using the heat pump and can be saved under certain circumstances.

In the following efficiency comparison it is clear how high the energy saving is with the heat pump. In order to obtain about 5 kW of heater output, about 5.5 kW of electrical power must be used for the electric heating (Index 2) due to resistor losses. A system with a heat pump (Index 1) only requires

about 2.5 kW of electrical energy in order to provide the same heater output of about 5 kW. The EKK consumes this electrical energy in order to compress the refrigerant and generate the heater output at the heat pump heat exchanger.

By using the heat pump electrical energy of up to 3 kW can be saved in favorable conditions. This energy can then be used for the electric motor of the vehicle, thereby increasing the range.

With the heat pump, electric heating is always installed in order to ensure guaranteed heating of the passenger compartment in the event of a system failure.



Efficiency of the heat pump in comparison to electric heating

Index	Explanation
1	Heat pump in heating mode
2	Electric heating
A	Heater output
B	Electrical energy consumption

The cooling circuit with this equipment only differs by the additional heat pump heat exchanger, which is installed between the coolant pump and electric heating.

Note: Use special "Coolant concentrate i3".

More information on the operating principle of the heat pump is provided in chapter 6.4.

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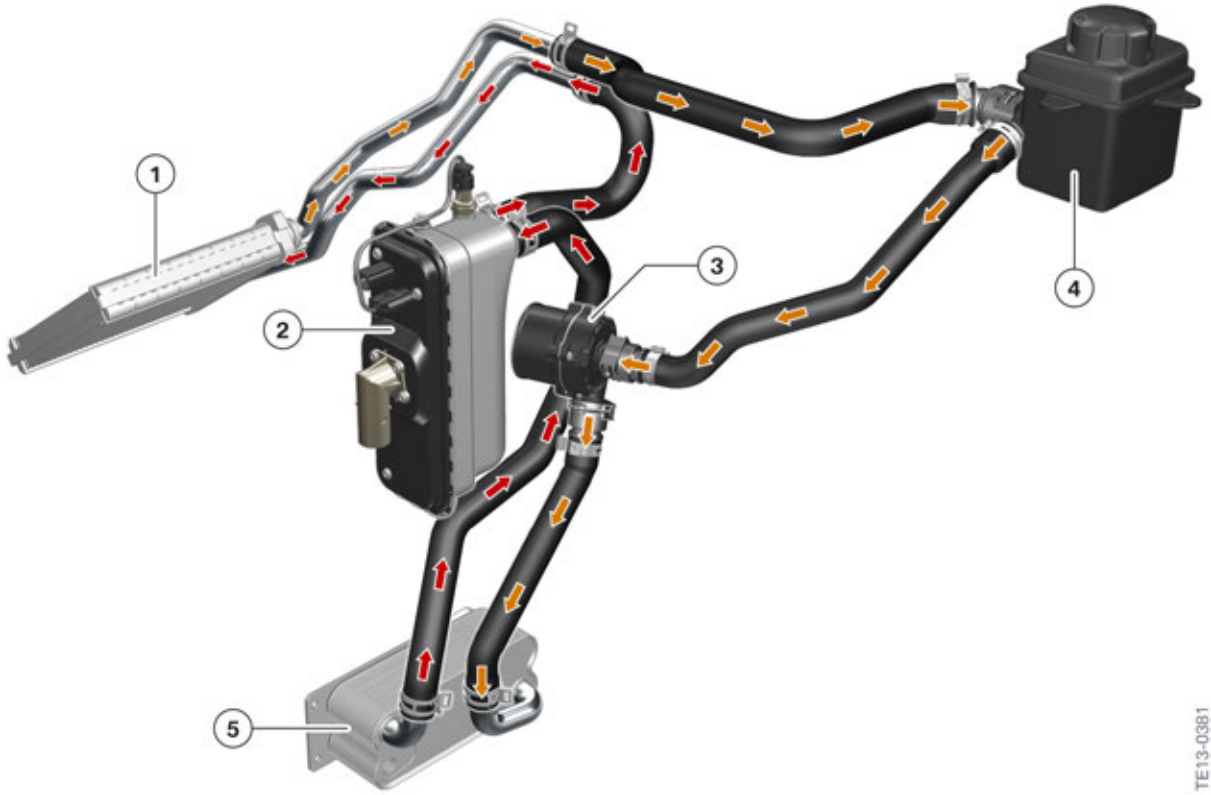
4. First Use in BMW i



Heating for the passenger compartment with heat pump

Index	Explanation
1	Heat exchanger in the passenger compartment
2	Electric heating
3	Electric coolant pump (12 V)
4	Coolant expansion tank
5	Heat pump heat exchanger

In the case of insufficient heat output from the heating, ensure correct bleeding of the heater coolant circuit and if necessary refill the system.

4.8. Coolant used for the heater circuit

For the heater circuit of the I01 the new coolant with the name **"Coolant concentrate i3"** is used.

Only use this coolant, otherwise it may cause the heater circuit to become damaged and clogged.

This green-colored coolant can **only** be used for the cooling circuit of the heating in the I01. The heater circuit is filled with about 1.9 liters in the mixture ratio of 50/50. Freeze protection up to -40 °C / -40 °F is achieved.

4.9. Heat pump

Why does the use of a heat pump in electric vehicles make sense?

In electric vehicles there is very little usable waste from the electrical machine and power electronics. Additional structural work is therefore not worthwhile in order to use this waste heat for heating effectively. Even if the I01 is equipped with a range extender, the waste heat from the combustion engine is not used. A combination of range extender with heat pump, is not offered for weight reasons.

So that the range of the electric vehicle is not reduced significantly by the electric heating, the heating of the passenger compartment is offered here taking into account the heating and air-conditioning system with a heat pump.

The heat pump can be viewed as a reverse principle of a heating and air-conditioning system. The heat energy, which is unused in cooling is lost to the surrounding area via the condenser, can be used for heating up the passenger compartment by redirecting the hot refrigerant to the heat pump heat exchanger.

A heat pump with the components installed in the vehicle enables the function of the heating and cooling modes, as well as mixed operation. With about 1 kilowatt of power about 3 kilowatt of cold air and about 2 kilowatt of heat can be acquired using this system. The electric heating used in the I01 requires about 5.5 kW of electrical energy in order to provide a heater output of about 5 kW. In the table below it is clear that the heat pump only requires about 2.5 kW for this heater output.

Energy use	Heater output	Cooling power
1 kW of electrical energy	2 kW	3 kW
2.5 kW of electrical energy	5 kW	7.5 kW

The operation of a heat pump in all its operating modes makes sense in a temperature range between –10 °C and +40 °C / 14 °F and +104 °F.

The heat pump is not an individual component, but a complex adaptation of a refrigerant circuit with an equally complex control structure.

In chapter 6.4 the heat pump is described in detail.

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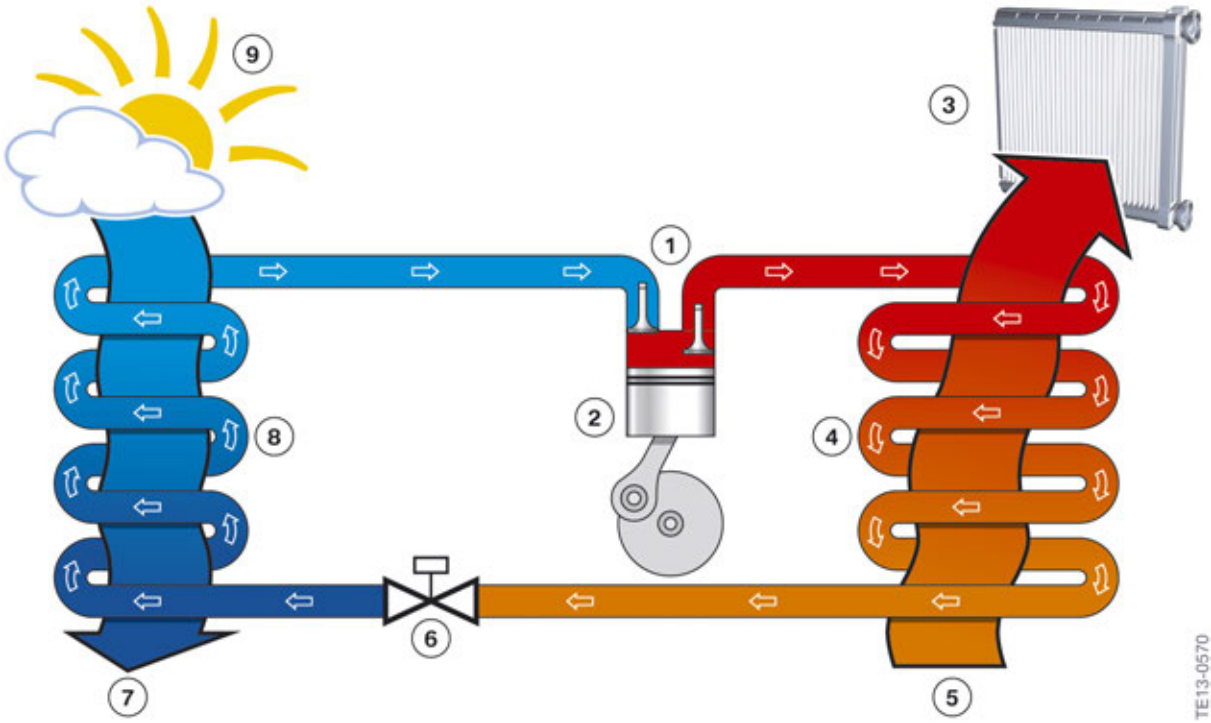
4. First Use in BMW i



Function diagram of a heat pump

Index	Explanation
1	Compress
2	Energy consumption 1/4
3	Heat pump heat exchanger
4	Useful heat 4/4
5	Reduce into a fluid state
6	Release by expansion valve
7	Evaporate
8	Ambient heat 3/4
9	Ambient temperature

The energy consumption at the compressor (Index 2) requires 1/4 energy to compress the refrigerant. The heat pump can use another 3/4 energy in the form of heat (Index 8) from the ambient heat (Index 8). For instance, 1/4 energy consumption added to 3/4 energy-neutral ambient heat gives 4/4 of usable heat (Index 4), which, for example, can be transferred to a heater circuit via a coolant.

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5. Stationary Cooling

I01 at a charging station

Both types of heating and air-conditioning systems can also be activated by the driver when the vehicle is stationary. The passenger compartment can be cooled and heated.

When the vehicle is parked for example in the blazing sun the heated interior temperature can be reduced within a few minutes by virtually half. The customer can activate the stationary cooling directly in the vehicle or by My BMW i Remote app on the iPhone® or iPad®. The passenger compartment of the vehicle is cooled considerably while the customer is not present. When the car is started the full cooling output is then available immediately without the heated warm air first coming through the air vents.

The stationary cooling offers a further advantage. The high-voltage battery unit can be cooled via the refrigerant circuit if required. The energy for the cooling is taken from the high-voltage battery. Even though the energy is initially consumed for this purpose, the energy consumption is overall considerably lower. The battery cells are operated in an optimal range (< 30 °C / 86 °F), thus increasing their efficiency and service life.

5.1. Prerequisites for stationary cooling

The stationary cooling can only be operated when the following preconditions are satisfied:

- The high-voltage battery is sufficiently charged
- The vehicle is connected to a charging station
- The charging power at the power socket must be at least 1.5 kW
- Windows and doors should be closed to increase the efficiency.

5.2. Displays in the vehicle

An activated stationary cooling is displayed by a flashing fan symbol on the display with a standby display below it. The selected temperature and air distribution are not shown on the display, nor is the blower output at the blower rocker switch. If the selection "Climate control for departure" is made, this activation is shown in orange on the display with a fan symbol and the standby display below it. Both symbols are illuminated in white for the active period and show the function is running.

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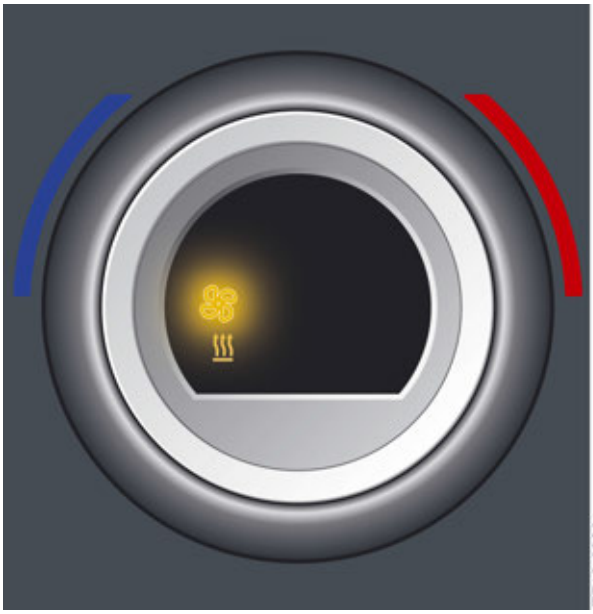
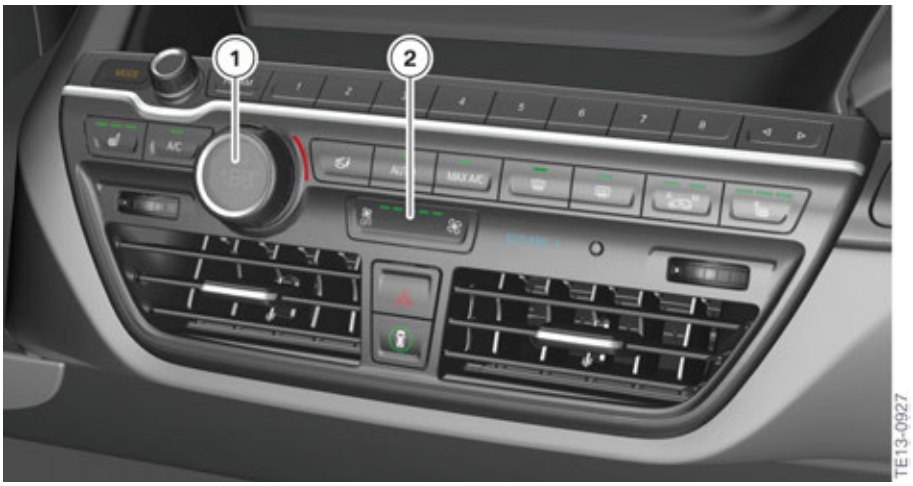
5. Stationary Cooling



Display for stationary mode

The display of the blower output is shown when driving with a bar display by LEDs at the blower rocker switch.

During an active stationary function the LEDs do not light up in the blower rocker switch.



Bar display for blower at the combined audio and heating and air-conditioning controls

Index	Explanation
1	Display
2	Bar display

5.3. Settings in the vehicle

Stationary cooling

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5. Stationary Cooling

With terminal 15 switched on the direct stationary cooling can be activated using the controller and the menu in the CID.

Preheating/Precooling

Up to three different departure times with an additional selection of the preheating/precooling can be set. The departure times can be adjusted by selecting the weekdays (check marks) and the time for each departure time one, two and three.

Example of planned preheating/precooling for the departure

Index	Explanation
1	Selection of time for departure time 1
2	Selection of departure time 1
3	Selection of preheating/precooling for departure
4	Selection of weekday for departure time 1

The selection of the preheating/precooling for the departure has the following advantages:

- Preheating/Precooling of the passenger compartment and optionally the high-voltage battery unit during the charging procedure at the departure time terminates
- Stationary air-conditioning of the passenger compartment
- Auxiliary heater function of the passenger compartment
- Cooling of the high-voltage battery unit to guarantee power during charging and driving.

5.4. Switching on and off using My BMW i Remote app

Using the My BMW i Remote app the customer can also control the stationary cooling outside the vehicle. According to a similar principle in the vehicle, the stationary cooling is started or stopped or a switch-on time is selected.

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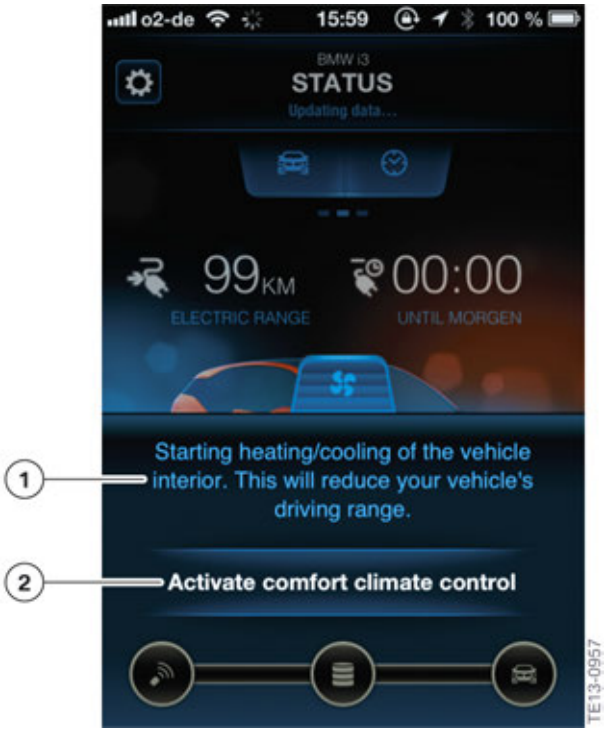
5. Stationary Cooling



Preheating/Precooling menu

Index	Explanation
1	Indication that the range is reduced if the vehicle is not charged during the preheating/precooling
2	Activation of preheating/precooling

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6. Components and Systems

6.1. Components

6.1.1. Integrated automatic heating and air-conditioning system components

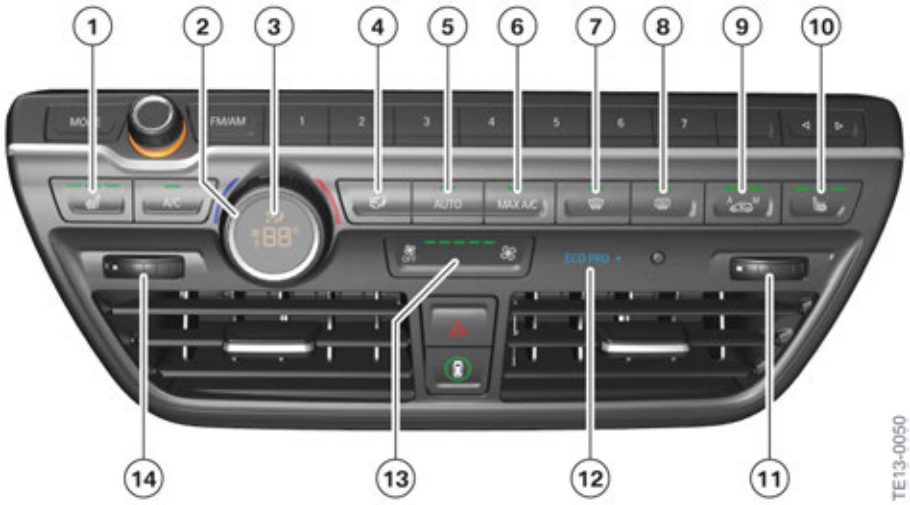
An integrated automatic heating / air-conditioning regulation is offered as standard equipment. The IHKA, with display in the temperature selector wheel has automatic temperature, air flap and blower control. The automatic air recirculation control, which enables the automatic air recirculation function, is also installed. The button for the air recirculation function has a dual function.

The combined audio and heating and air-conditioning controls sends signals via a Local Interconnect Network data bus to the IHKA control unit. If required the requests can be sent to the corresponding control units or components via the K-CAN4.

The control unit is not integrated in the control panel, but bolted on at the left side at the heating and air-conditioning unit.

The illuminated blue ECO PRO or also ECO PRO + display can only be displayed and also indicates the activated operating mode.

Control panel and control unit.



Combined audio and heating and air-conditioning controls in the IHKA

Index	Explanation
1	Button for seat heating, left
2	Temperature selector wheel **automatic** control of the temperature for the driver's side **and** passenger's side, with display
3	Display for temperature, air distribution and fan symbol
4	Button for manual air distribution
5	Button for automatic program
6	Button for maximum cooling power
7	Defrost function button

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6. Components and Systems

Index	Explanation
8	Heated rear window button
9	Button with dual function: Air recirculation function **and** automatic air recirculation function
10	Button for seat heating, right
11	Knob for center vent on passenger's side
12	Display of ECO PRO or ECO PRO + mode by blue writing upon activation
13	Blower speed control
14	Knob for center vent on driver's side

Automatic function

- Automatic control of air distribution, no range of adjustment.
- Automatic control of blower output, no range of adjustment.

Manual operation

- The air distribution can be changed by pressing the button for manual air distribution several times. The selected air distribution (top, center, bottom) is displayed by an arrow symbol on the display.
- The blower intensity can be controlled manually using the rocker switch for the blower output.

ECO PRO mode

The ECO PRO mode supports a very efficient driving style. It influences the driving power and reduces the power for lighting and convenience functions or switches them off.

This mode is selected by pressing the driving experience switch. The corresponding driving mode is displayed in the instrument cluster and by illuminated blue ECO PRO writing in the combined audio and heating and air conditioning controls.

The interior air temperature control of the passenger compartment is controlled economically. A slight deviation to the set temperature and slower interior air temperature control of the passenger compartment is therefore possible for energy consumption.

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6. Components and Systems

Driving experience switch, touch controller and PDC button

The following climate functions cannot or can only partially be activated or adjusted when ECO PRO mode is active:

- Temperature setpoint adaptation depending on the ambient conditions
- Delayed cooling
- Power reduction of seat heating and mirror heating
- Evaporator control
- Heating with recirculated air flap control.

ECO PRO + mode

Instrument cluster with activated ECO PRO + mode

This mode can be selected by pressing the driving experience switch again and also has further energy-saving effects in addition to ECO PRO mode. In addition to the illuminated blue writing of ECO PRO mode in the combined audio and heating and air-conditioning controls. The "+" symbol also appears. The display in the temperature selector wheel at the control panel is also deactivated.

Effects when ECO PRO + mode is activated:

- No rear window defrosting
- Deactivation of cooling power and heater output for the passenger compartment
- Deactivation of the seat heating
- Restriction of the speed to a maximum value of 90 km/h / 55 mph. The vehicle speed limit can be overridden by pressing the accelerator pedal.

Heated rear window

The heated rear window is supplied with voltage via a relay in the Body Domain Controller. A 30 amp fuse in the Body Domain Controller protects the system against a short circuit and overload. As usual, the heated rear window has two wave traps.

The button for switching the heated rear window is located in the combined audio and IHKA controls.

After pressing the button the integrated green LED illuminates and displays the activated state. The heated rear window automatically switches off after a pre determined time and the LED goes out.

Heating and air-conditioning unit

In the I01 a new heating and air-conditioning unit is used.

Properties of the heating and air-conditioning unit:

- 1-zone IHKA
- No left-right separation
- No rear-seat area ventilation
- No adjustable stratification (this happens automatically)
- Air flow by flaps
- No variants: Only differentiated by different expansion valves depending on equipment
- 2-part microfilter. This can be replaced from the right passenger compartment by a Service flap.

The passenger compartment temperature is controlled using an air flap in the heating and air-conditioning unit. A water valve is not used as the air flow can be directed continuously by the air flap in the heat exchanger. This is called temperature control on the air side..

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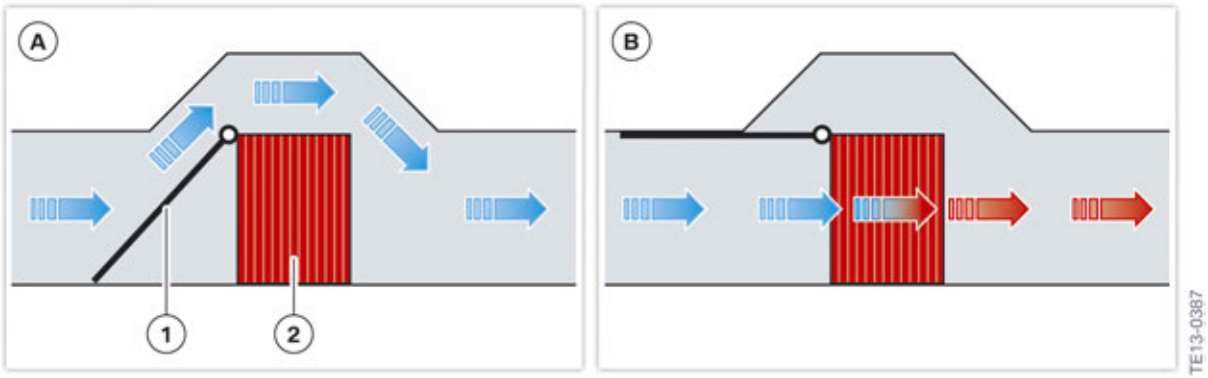
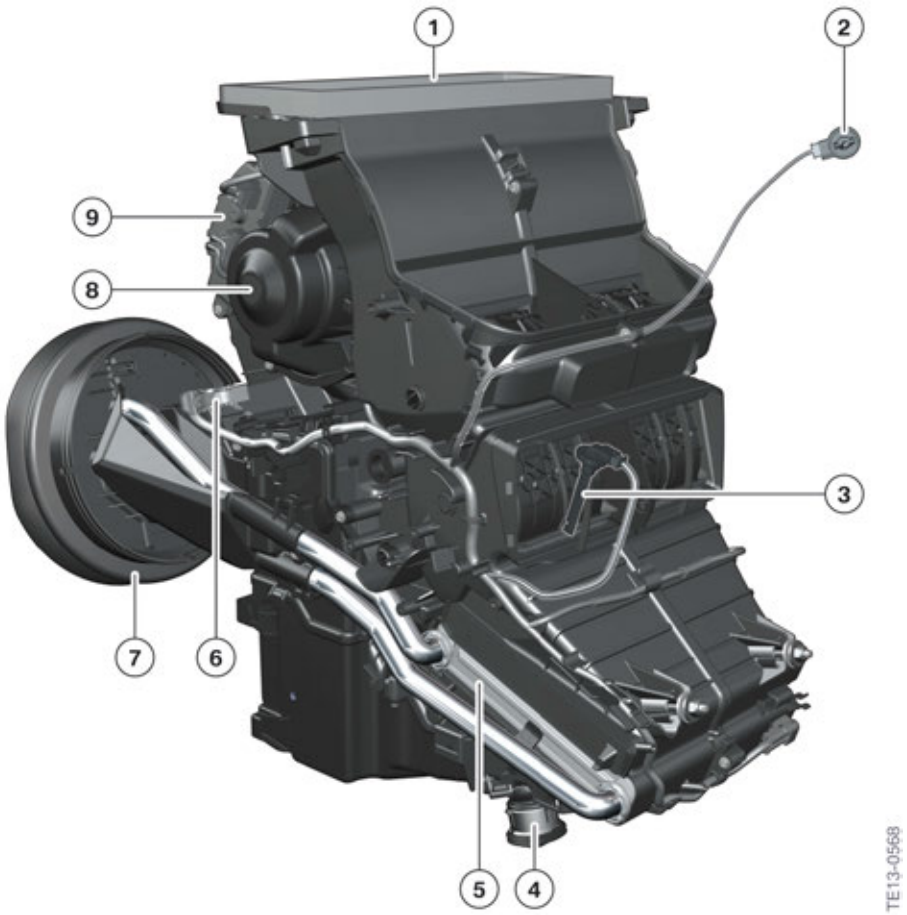
6. Components and Systems



Air temperature control

Index	Explanation
A	No heating, the air is directed **around** the heat exchanger
B	Heating, the air is directed **through** the heat exchanger
1	Air flap
2	Heat exchanger



Heating and air-conditioning unit

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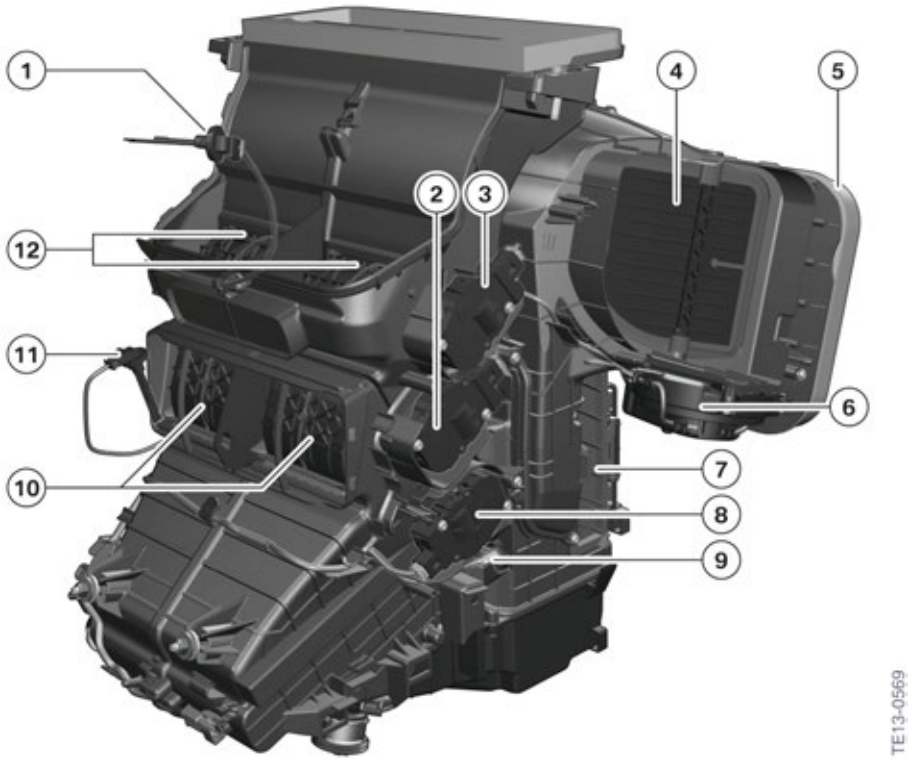
6. Components and Systems

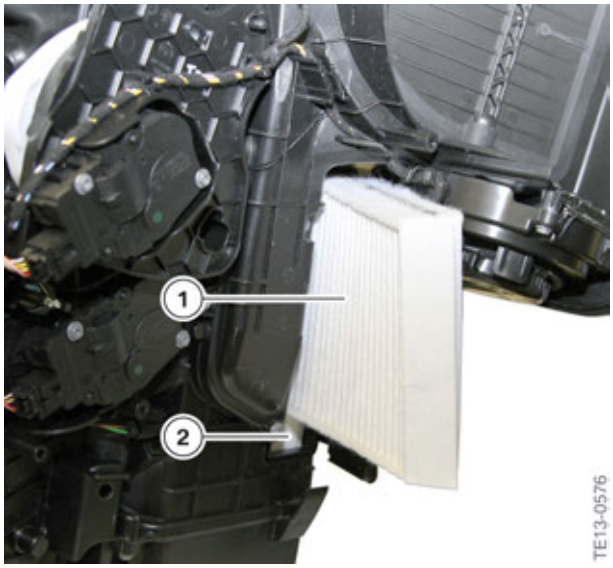
Index	Explanation
1	Air vent, top
2	Temperature sensor, center vent
3	Temperature sensor, footwell air outlet
4	Discharge of condensation from the heating and air-conditioning unit
5	Heat exchanger
6	Connector at the control unit for IHKA
7	Connection, bulkhead
8	Blower motor
9	Blower output stage



Heating and air-conditioning unit

Index	Explanation
1	Temperature sensor, center vent
2	Stepper motor for footwell air outlet, left and right
3	Stepper motor for defrost function
4	Recirculated air flap
5	Ambient air intake area at the bulkhead
6	Stepper motor for recirculated air flap (with kinematics control)

Index	Explanation
7	Service flap of two microfilters
8	Stepper motor for blending flap
9	Evaporator temperature sensor
10	Air flaps, footwell air outlet
11	Temperature sensor, footwell air outlet
12	Air flaps, center vent



Heating and air-conditioning unit, replacement of microfilter

Index	Explanation
1	Upper microfilter
2	Lower microfilter

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6. Components and Systems

Heating and air-conditioning unit, replacement of microfilter

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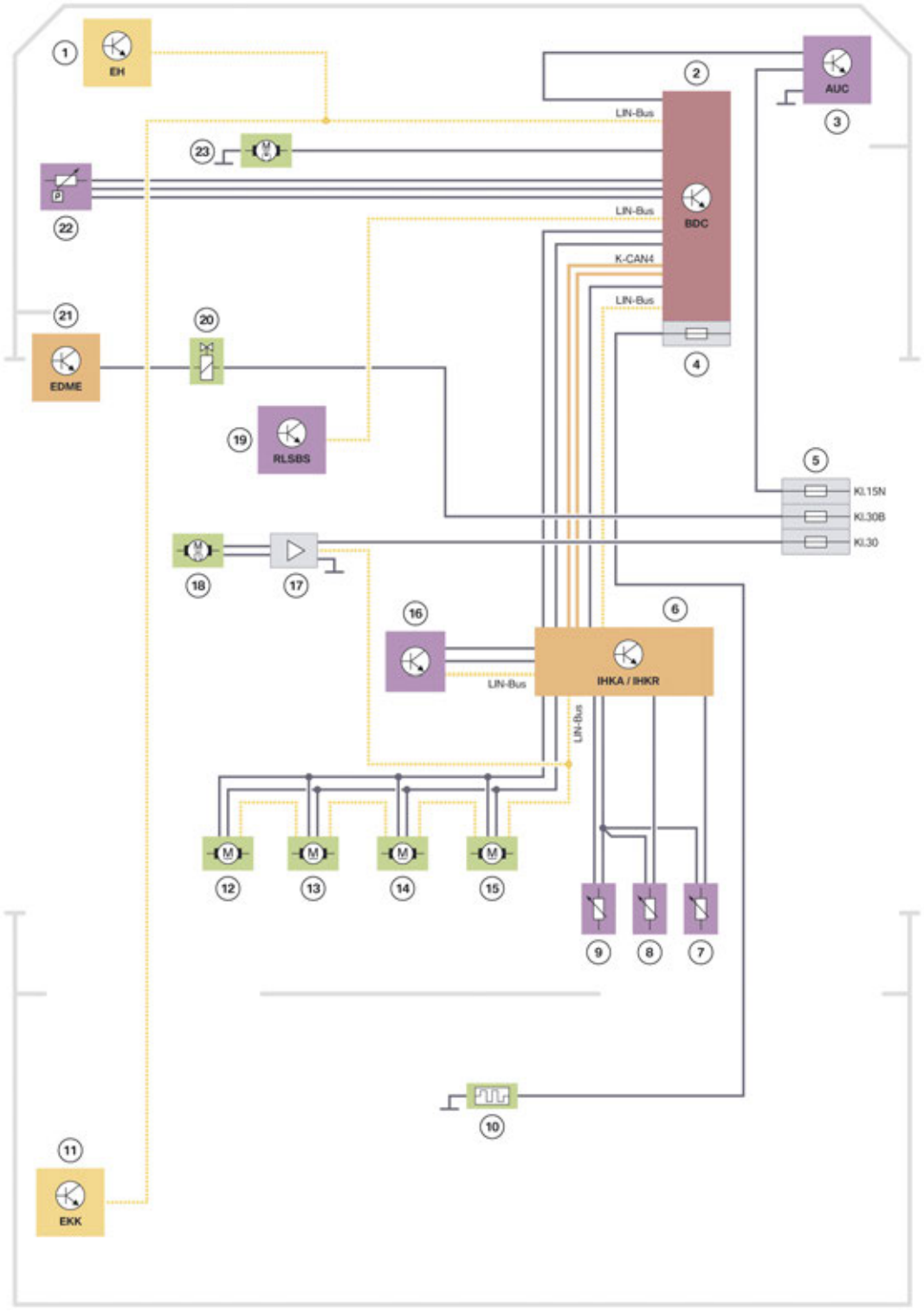
6. Components and Systems



Wiring diagram for integrated automatic heating and air-conditioning system IHKA

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6. Components and Systems

Index	Explanation
1	Electric heating
2	Body Domain Controller (BDC)
3	Automatic air recirculation control sensor
4	Fuse for heated rear window, 30 amp
5	Fuse network for: Blower 40 amp, electrically controlled Expansion valve (ETXV) at the high-voltage battery unit 5 amp and Automatic air recirculation control sensor 5 amp
6	IHKA control unit
7	Evaporator temperature sensor
8	Temperature sensor, center vent
9	Temperature sensor, footwell air outlet
10	Wave traps, heated rear window
11	EKK
12	Stepper motor flaps for footwell air outlet, left and right
13	Stepper motor flaps for defrost function
14	Stepper motor for fresh air/air recirculation function
15	Stepper motor, blending flap
16	Combined audio and heating and air-conditioning controls
17	Blower output stage with Local Interconnect Network bus control
18	Blower for passenger compartment
19	Rain-light-solar-condensation sensor
20	Combined expansion and shutoff valve for the evaporator in the heating and air-conditioning unit (is controlled via the EDME)
21	EDME control unit
22	Refrigerant pressure sensor for switching off in the event of excess pressure in the refrigerant circuit
23	Coolant pump (in the standard equipment without heat pump, there is no pulse-width modulated signal)

Stepper motors

The stepper motors, which ensure air distribution and air mixing within the heating and air-conditioning unit, are activated via a local interconnect network bus and named as follows:

- Stepper motor, footwell
- Stepper motor, blending flap
- Stepper motor, defrost function
- Stepper motor with kinematics for fresh air/air recirculation function.

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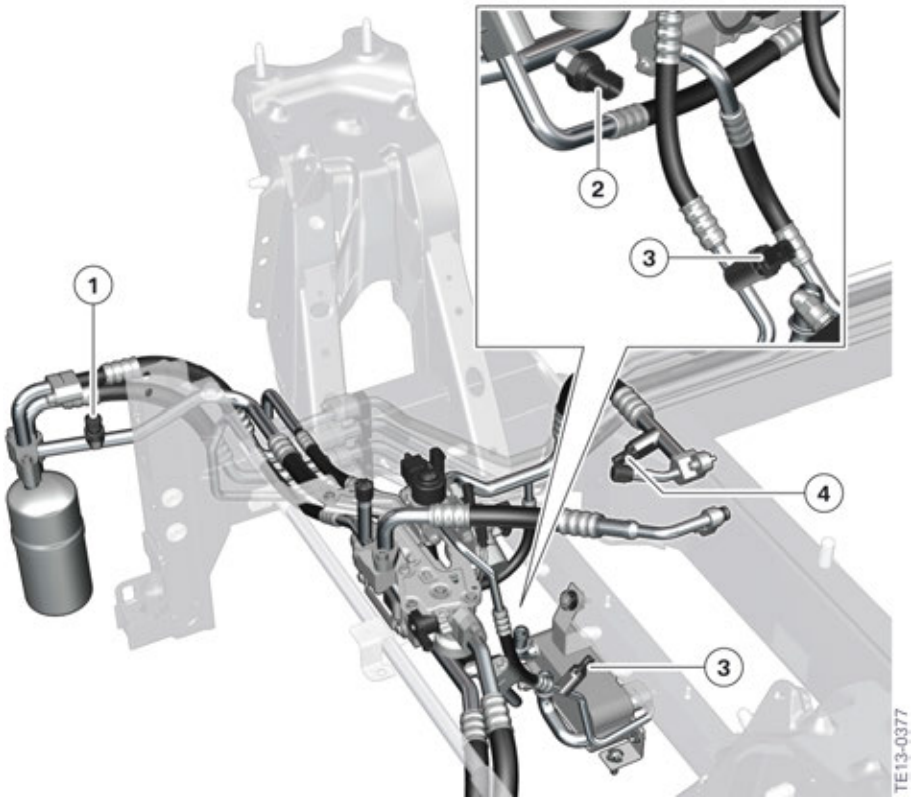
Sensors

The installed sensors supply information to the IHKA control unit.



Refrigerant pressure sensor IHKA, in the graphic with heat pump, I01 BEV

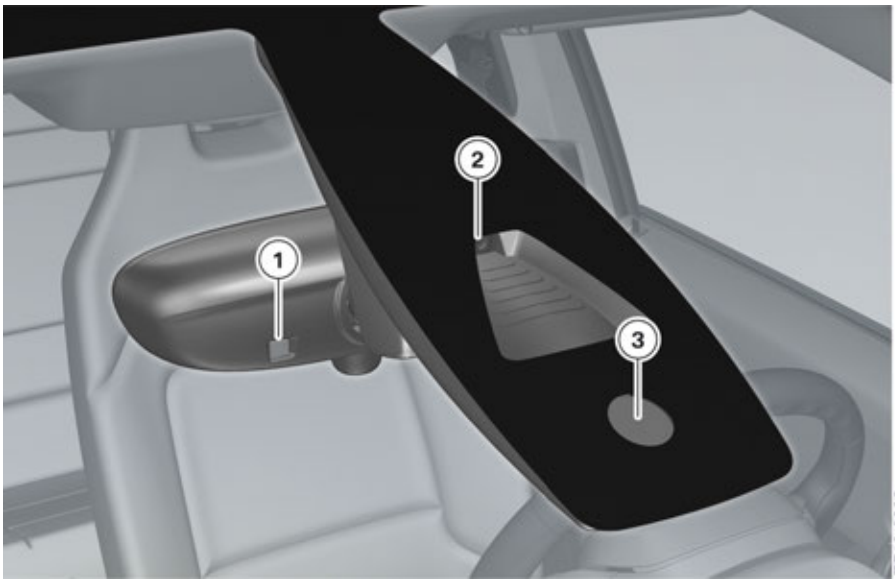
Index	Explanation
1	Refrigerant pressure-temperature sensor 1 with heat pump
2	Refrigerant pressure sensor for switching off in the event of excess pressure in the refrigerant circuit
3	Refrigerant temperature sensor 1 with heat pump
4	Refrigerant temperature sensor 3 with heat pump

The refrigerant pressure sensor switches off the EKK in the event of excess pressure in the refrigerant circuit in order to avoid damage to the system. The sensor is integrated in the refrigerant line. It is monitored by the Body Domain Controller.

The NTC sensors in the heating and air-conditioning unit are read in and evaluated by the IHKA control unit. Values for the vent temperature of the footwell and the center vent, as well as the evaporator temperature, are recorded here.

In the I01 a rain-light-solar-condensation sensor is installed at the windshield, similar to other BMW vehicles.

The signals are transmitted via a Local Interconnect Network data bus to the Body Domain Controller. The values are made available to various systems in the vehicle and are requested for the climate control by the IHKA control unit.



Rain-light-solar-condensation sensor

Index	Explanation
1	Photosensor for electrochromic mirror
2	KAFAS camera
3	Rain-light-solar-condensation sensor

6.2. High-voltage components

⚠

Only Service employees who are certified and have completed all of the prerequisites are permitted to work on the designated high-voltage components: suitable qualifications, compliance with the safety rules, procedure following the repair instructions **exactly**.

The diagnosis and repair of the high-voltage components is only allowed in a retail service center that has qualified and certified service technicians. These technicians must have completed the ST1403b I01 High-voltage Battery and Maintenance instructor led course and successfully passed the hands-on certification.

6.2.1. EKK

The designation EKK refers to the entire system. The EKK comprises the following components:

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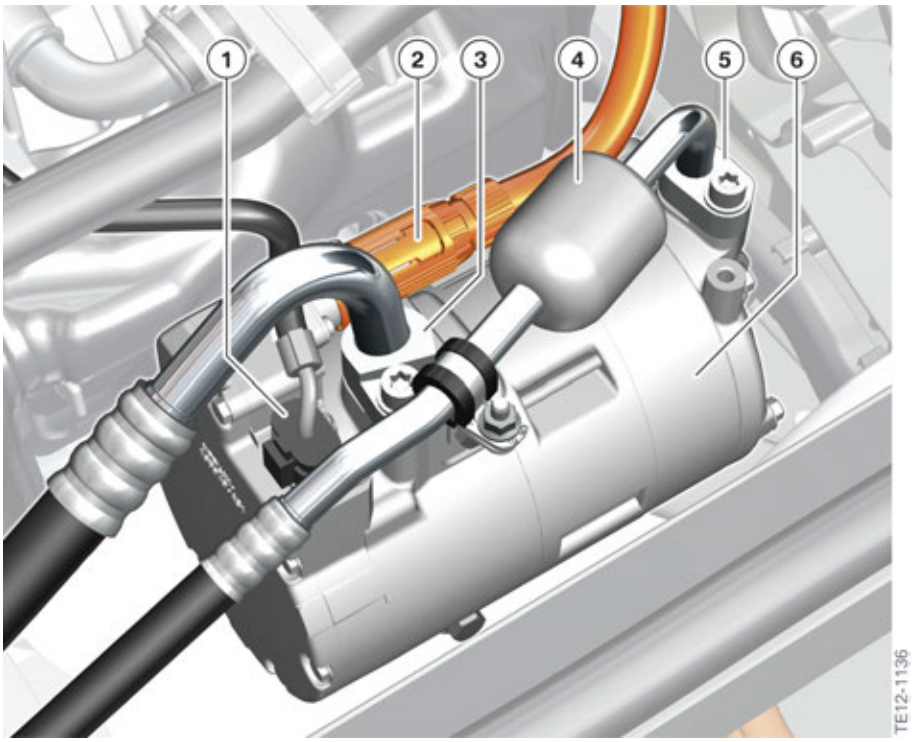
- Housing
- EKK control unit
- Three-phase current synchronous motor
- AC inverter
- Air-conditioning compressor

These individual components are never replaced separately! The EKK is always replaced a a unit.



EKK

Index	Explanation
1	Low-voltage connector (local interconnect network bus, 12 V voltage for EKK control unit)
2	High-voltage connector
3	Connection for intake pipe
4	Silencer (ensures acoustic comfort)
5	Connection for pressure line
6	EKK

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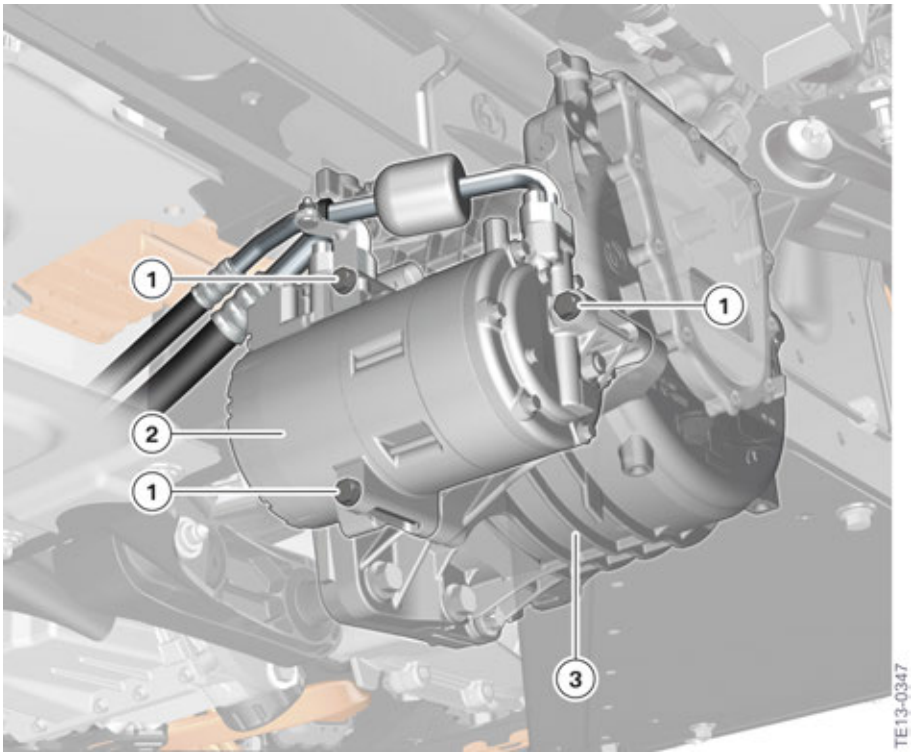


Installation location of EKK

Index	Explanation
1	Bolt connection for the electrical machine
2	EKK
3	Electrical machine

The newly developed EKK from the manufacturer Visteon is built according to the principle of a scroll compressor. It obtains its energy from the high-voltage battery and has a maximum power consumption of up to 4.5 kW. The component is located in the rear and is mounted on to the electrical machine.

An integrated three-phase current synchronous motor in the EKK is used as an electric motor. The necessary three-phase current is converted in the EKK using an AC inverter (DC/AC converter).

The three-phase synchronous motor is operated in the engine speed range from 860 to a maximum of 8600 RPM's. When stationary the speed of the EKK is restricted to 60 % of the maximum speed, i.e. 5160 RPM's. The EKK can generate a maximum operating pressure of about 30 bar. The maximum power is required, for example, at high ambient temperatures, high interior temperatures, high temperatures of the high-voltage battery and low air flow of the cooling module.

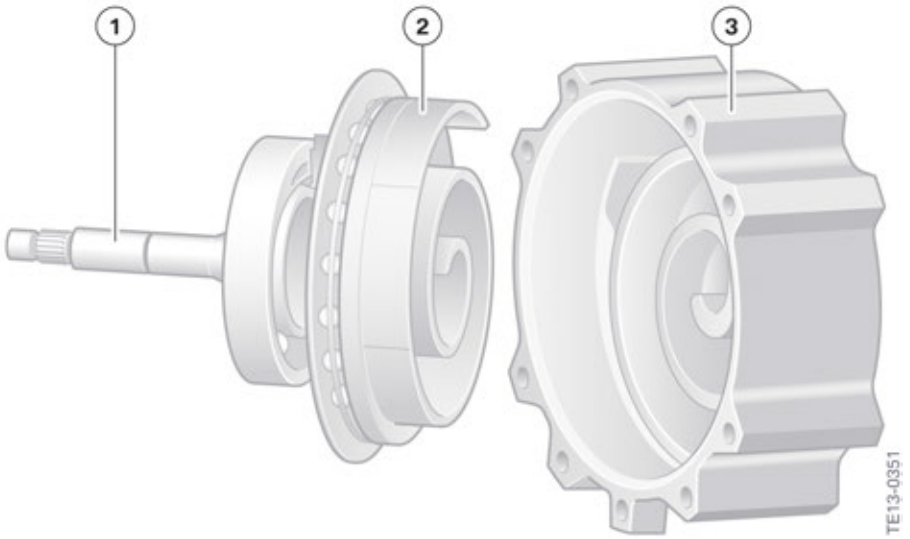
The speed of the three-phase current synchronous motor controls the EKK control unit integrated in the EKK depending on the requirements of the IHKA via the local interconnect network bus. The IHKA control unit is the main control unit.

The supply voltage for the EKK has a voltage range (DC) of about 200 V to 410 V. The power is reduced above and below this voltage range or the EKK is switched off.

The EKK control unit and the DC/AC converter are integrated in the aluminium housing of the EKK and are cooled by refrigerant flowing around it. If the temperature of the DC/AC converter exceeds 125 °C / 257 °F, the high-voltage supply is shut off by the EKK control unit. An attempt is made through different measures such as speed increase for cooling, initially the temperature is not allowed to rise so high. The temperature monitoring is effected by the EKK. If the temperature drops below 112 °C / 233 °F, the EKK continues to run.

As with all current BMW vehicles R134a refrigerant is used in the system.

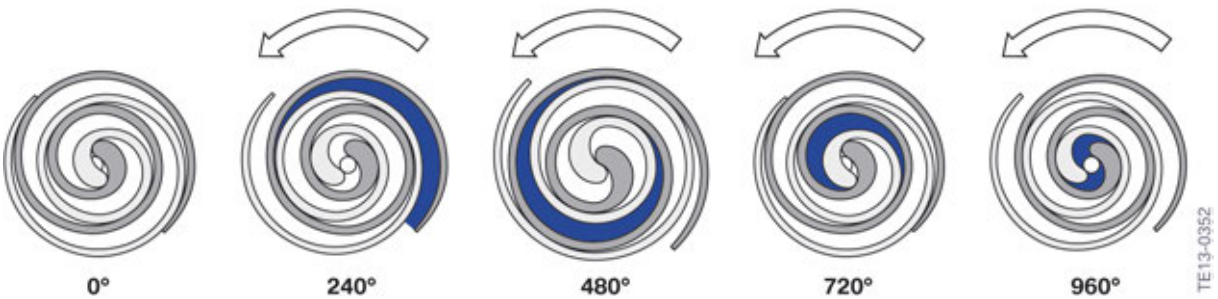
Further information on the topic of refrigerant oil can be found in chapter 4.5 of this training reference manual.



Discs with spiral profile in the EKK

Index	Explanation
1	Shaft
2	Inner disc with spiral profile
3	Outer disc with spiral profile

Procedure for the compression of the refrigerant



Refrigerant compression in the EKK

The inner disc with spiral profile is driven via a shaft by the three-phase current synchronous motor and rotates eccentrically. The gaseous refrigerant at low temperature and low pressure is drawn in through two openings in the fixed outer disc with spiral profile and compressed and heated by the movement to the center of the two discs with spiral profiles.

After three eccentric revolutions, the refrigerant drawn in is compressed and heated and can escape in a gaseous state through an opening in the center of the outer disc. From here, gaseous refrigerant with high temperature and high pressure escapes via an oil separator at the connection of the EKK towards the refrigerant circuit.

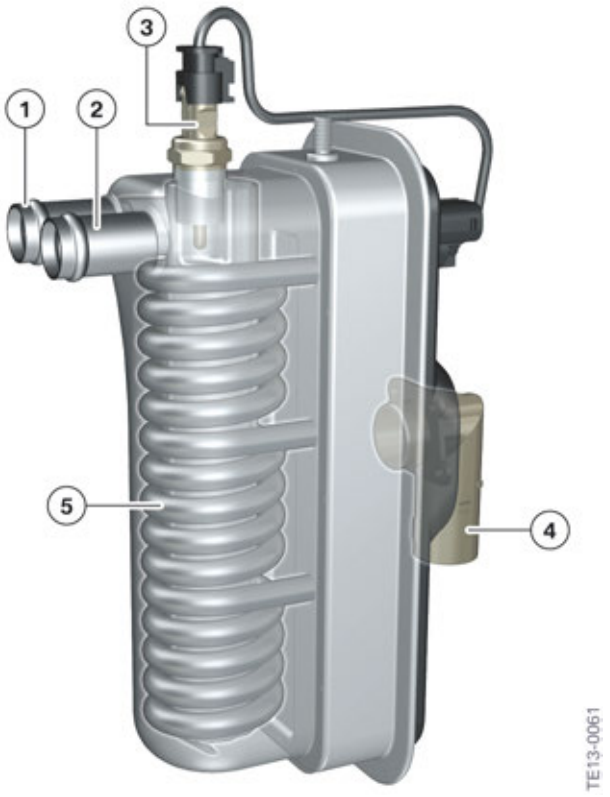
For more information and details please refer to the "I01 High-voltage Components" training manual.

6.2.2. Electric heating

For heating the passenger compartment electric heating is installed, which heats up the coolant similar to an immersion heater.

This high-voltage component is made up of three heater coils and an electronic control. It uses power of up to 5.5 kW from the high-voltage battery and sends information on the coolant temperature at the outlet, as well as about the current power consumption, via the Local Interconnect Network data bus to the IHKA control unit. The three heater coils are activated synchronously.

The electric heating is located at the bulkhead on a bracket with the electric coolant pump.



Electric heating

Index	Explanation
1	Coolant supply from the electric coolant pump (12 V) or with the heat pump heat exchanger
2	Coolant return to the heat exchanger for the passenger compartment
3	Coolant temperature sensor for coolant outlet temperature
4	High-voltage connection
5	Heater coils

For more information and details please refer to the "I01 High-voltage Components" training manual.

6.2.3. High-voltage battery unit

Repair of the high-voltage battery is only allowed in a retail service center that has qualified and certified service technicians. These technicians must have completed the ST1403b I01 High-voltage Battery and Maintenance instructor led course and successfully passed the hands-on certification.

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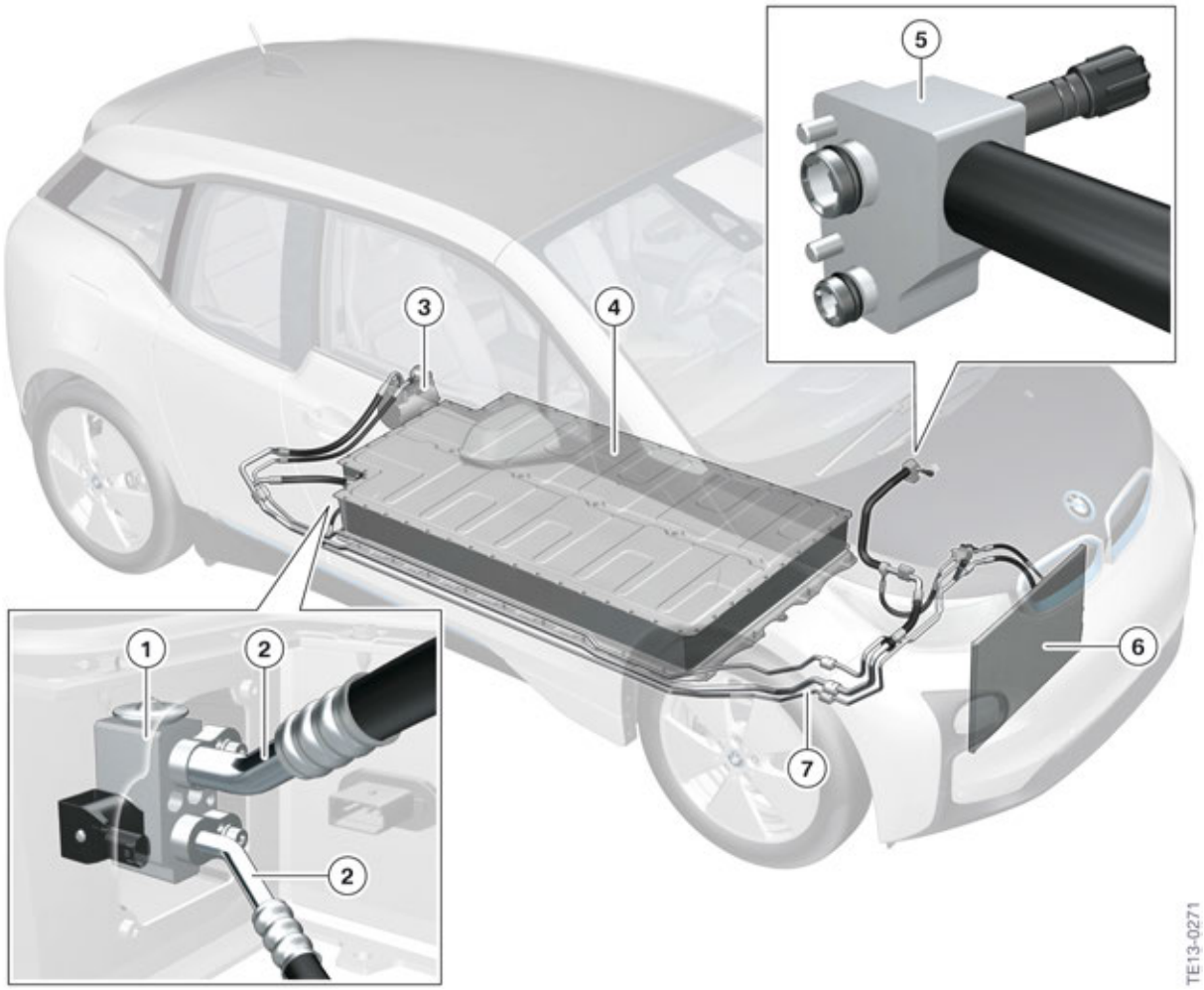

Cooling system of the high-voltage battery unit

Index	Explanation
1	Combined expansion and shutoff valve (ETXV) or electrically controlled expansion valve (EXV) with heat pump
2	Refrigerant lines at the high-voltage battery unit
3	EKK
4	High-voltage battery unit
5	Expansion valve (ETXV) for cooling the passenger compartment or (EXV) with heat pump
6	Condenser in the refrigerant circuit
7	Refrigerant lines

The high-voltage battery unit mounted on the Drive module under the vehicle is cooled using the existing air-conditioning system in the vehicle. The SME can independently trigger an activation of the electrical expansion valve and an activation of the cooling if required in order to counteract a power loss. If the cooling power is not sufficient, the expansion valve for the passenger compartment can also be activated.

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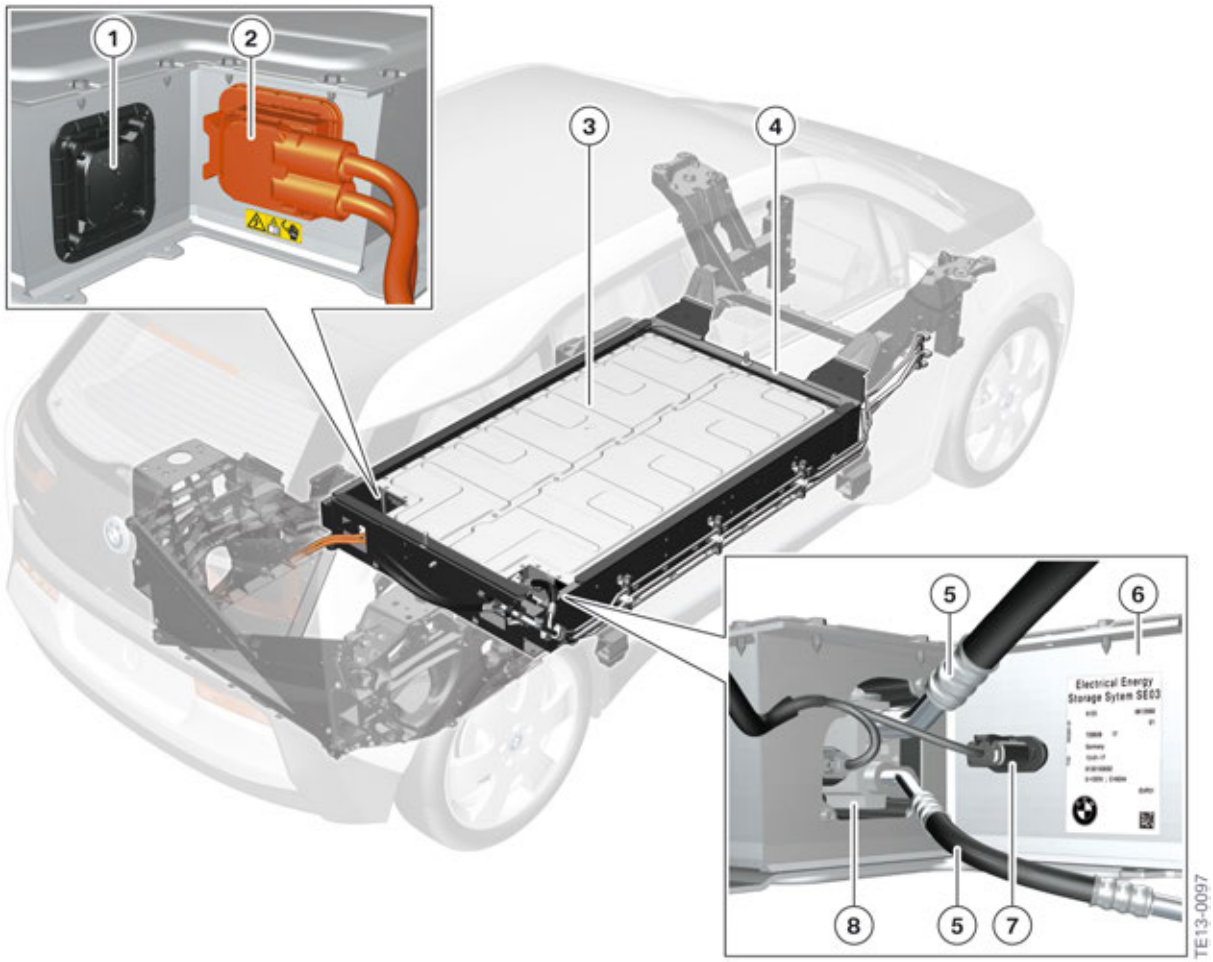
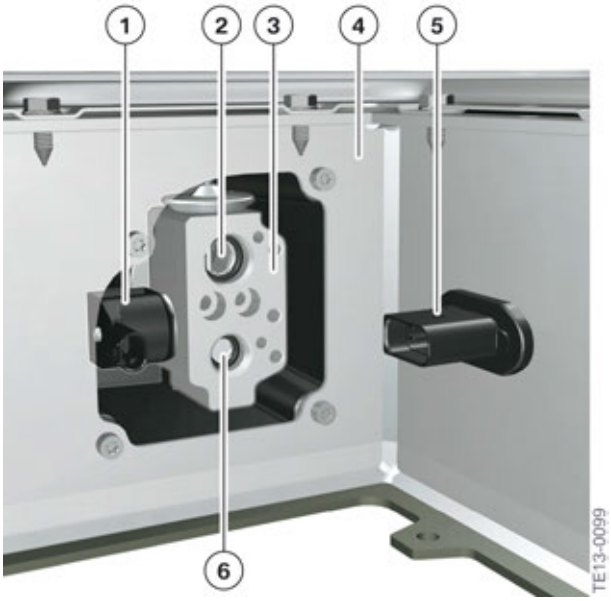
Further information on this can be found in the "I01 High-voltage Battery Unit" training manual.



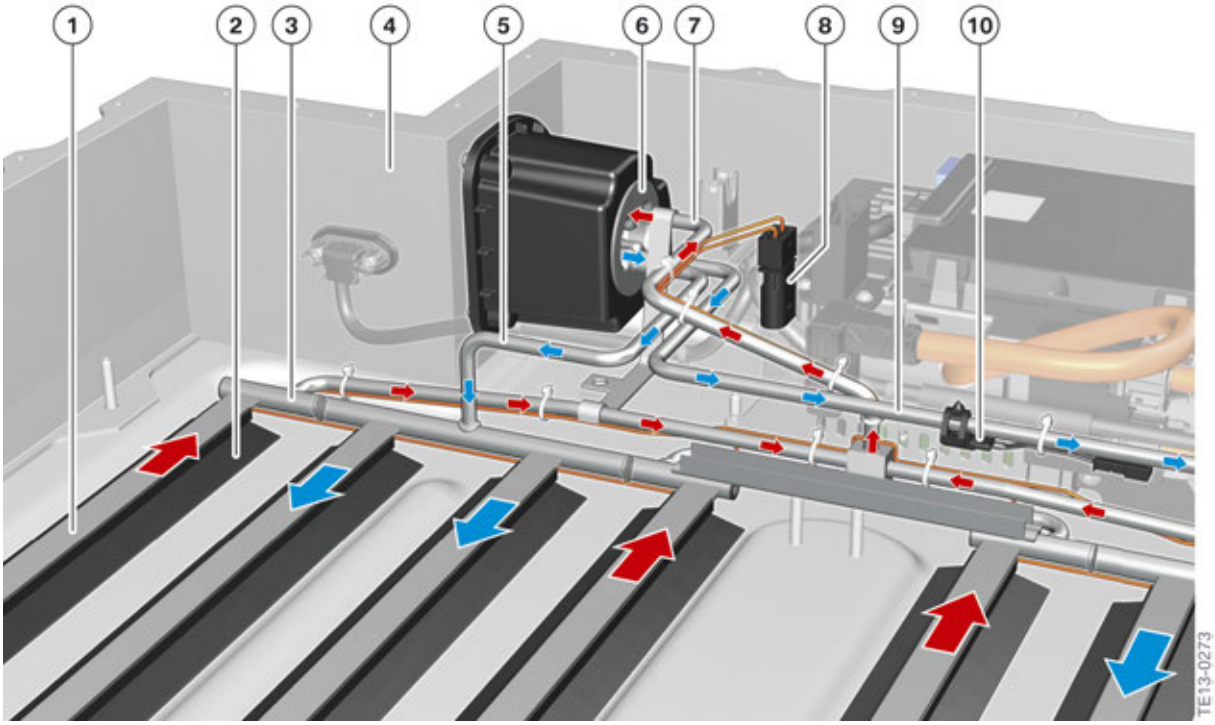
Housing of high-voltage battery

Index	Explanation
1	Vent
2	High-voltage connection
3	High-voltage battery unit
4	Frame (Drive module)
5	Refrigerant lines
6	Label
7	Low-voltage connection
8	Combined expansion and shutoff valve (ETXV) or electrically controlled expansion valve (EXV) with heat pump



Connection of refrigerant lines at the high-voltage battery unit

Index	Explanation
1	Connection for combined expansion and shutoff valve
2	Connection for refrigerant intake pipe
3	Combined expansion and shutoff valve (ETXV) or electrically controlled expansion valve (EXV) with heat pump
4	Housing of high-voltage battery unit
5	Low-voltage connection of the high-voltage battery unit
6	Connection for refrigerant pressure line



Cooling pipes of the high-voltage battery

Index	Explanation
1	Cooling grid
2	Spring strip
3	Connecting pipe at the cooling grid with disconnections for the supply and return cooling loops
4	Housing of high-voltage battery unit
5	Refrigerant supply
6	Combined expansion and shutoff valve (ETXV) or electrically controlled expansion valve 9EXV) with heat pump
7	Refrigerant return
8	Connection for electric heating in the high-voltage battery unit
9	Refrigerant supply
10	Temperature sensor of refrigerant line for the battery management electronics (SME)

The entire cell carrier must be dismantled for the replacement of the cooling loops in the high-voltage battery unit. The following work must be performed here:

- Removal of the SME, cell supervision circuits and all cell modules
- Removal of the safety box
- Replacement of the cooling loops in the high-voltage battery
- Installation of the safety box, SME, cell supervision circuits and the cell modules in reverse order.

For more information and details please refer to the "I01 High-voltage Components" training manual.

6.2.4. Cooling for electrical machine electronics

The electrical machine electronics is cooled together with the electrical machine and the convenience charging electronics by a separate cooling circuit.

For more information and details please refer to the "I01 High-voltage Components" training manual.

6.3. Refrigerant circuit/Cooling circuit for the heating

6.3.1. Quantities

Coolant quantity for the heating system

The coolant quantity in the heating system is about 1.9 liters in all I01 versions. The additional heat pump heat exchanger makes this hardly noticeable.

The system cannot be filled with the usual coolant, it flocculates. A new coolant with the designation "Coolant concentrate i3" is therefore used for this small circuit. This coolant **cannot** be mixed with other coolants. An appropriate warning sticker on the coolant expansion tank indicates the use of the new coolant.

Refrigerant quantity

The refrigerant circuit in the I01 with range extender is filled with 750 g (1.65 lbs). The quantity must be increased to 970 g (2.13 lbs) if the I01 is a BEV.

Refrigerant oil quantity

In the refrigerant circuit 230 g (0.5 lbs) of refrigerant oil for an I01 with the range extender and 300 g (0.66 lbs) for the I01 with out a range extender with the additional heat pump.

Please observe the notes on the new refrigerant oil as described in chapter 4.5. of this training reference manual.

As refrigerant and oil quantity is crucial for the operation of the cooling system; ways refer to the proper repair instructions and specifications (found in ISTA) when working on any refrigerant system.

6.3.2. Components

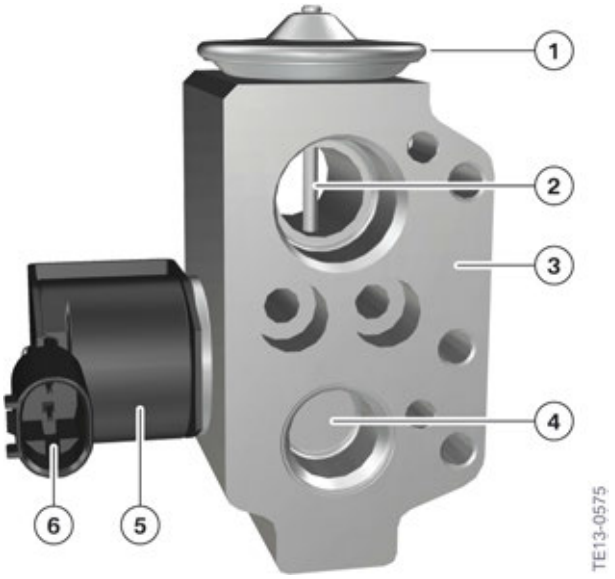
The combined expansion and shutoff valve (ETXV), which also has a shutoff function in addition to the thermal control, is **only** located at the high-voltage battery unit for the integrated heating and air-conditioning regulation.

A combined expansion and shutoff valve (ETXV) is also used for the evaporator of the passenger compartment.

By using the combined expansion and shutoff valve (ETXV) both cooling circuits for the cooling of the high-voltage battery unit and the passenger compartment can be opened and closed independent of each other.

An electrically controlled expansion valve (EXV), which is only installed with the I01 with out the range extender equipped with a heat pump replaces **all** expansion valves described here at the evaporator for the passenger compartment and at the high-voltage battery unit. A third electrically controlled expansion valve (EXV), as well as four refrigerant shutoff valves, are also installed with this equipment.

The electrically controlled expansion valves (EXV) are described in detail in chapter 6.4.2 Heat pump of this training manual.



Combined expansion and shutoff valve (ETXV)

Index	Explanation
1	Gas-filled diaphragm
2	Low-pressure channel
3	Housing of combined expansion and shutoff valve
4	High-pressure channel
5	Electric motor for combined expansion and shutoff valve
6	Signal connector

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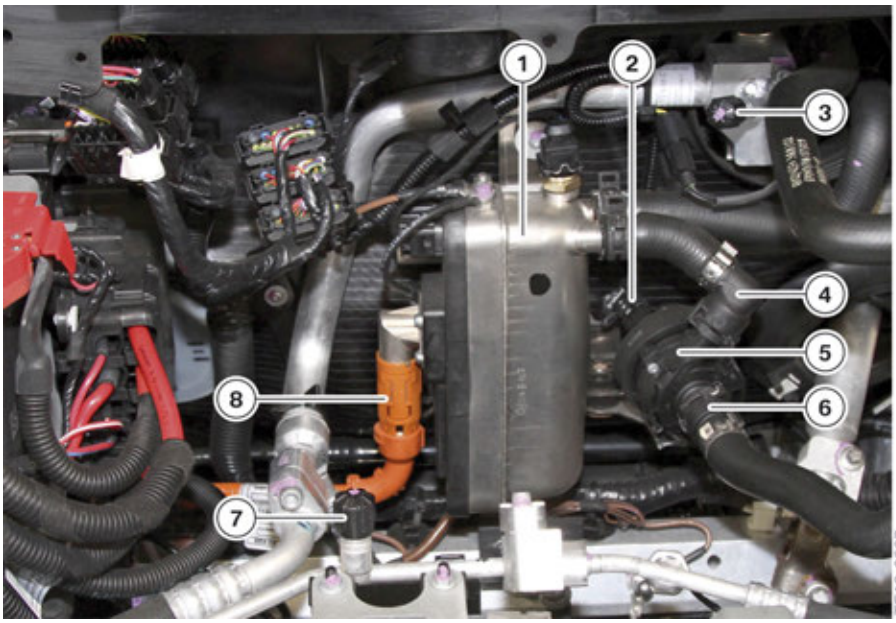
Electric coolant pump (12 V)



General view under the engine compartment lid after disassembly of the plastic cover

Index	Explanation
1	Electric heating
2	Coolant pump, 12 V connection
3	Filling valve, low pressure (black screw cap = R134a)
4	Coolant supply from the coolant pump to the electric heating
5	Electric coolant pump (12 V)
6	Coolant supply from the expansion tank
7	Filling valve, high pressure (black screw cap = R134a)
8	High-voltage connection at the electric heating

The cooling circuit for heating the passenger compartment is kept in circulation using an electric coolant pump (12 V) with 20 W power depending on the requirements from the IHKA control unit.

The coolant pump is located in the front on a bracket with the electric heating. The voltage supply and direct activation are effected via the Body Domain Controller, which receives the request via the K-CAN4 from the IHKA control unit.

The electric coolant pump (12 V) runs at full speed or is switched off completely. It delivers the coolant from the coolant expansion tank to the electric heating.

I01 vehicles with the heat pump, the heat pump heat exchanger is installed in series between the coolant pump and electric heating.

The electric coolant pump (12 V) with the heat pump is switched and regulated by the additional heat pump controller by a pulse-width modulated signal from 0 to 50 % and continuously from 50 o 100 %. In the housing of the coolant pump the electronics evaluate the pulse-width modulated signal coming from the heat pump controller, adjust the speed of the electric coolant pump and the circulation speed of the coolant.

The same coolant pump is installed in both versions. However, the center pin 2 in the connector is not occupied in the standard equipment. The pulse-width modulated signal is missing in this equipment specification as there is no heat pump controller.

Heat exchanger

The heat exchanger is installed in the heating and air-conditioning unit and is made from solid aluminium. The air flowing through is directed via the regulated air switches through the discs of the heat exchanger. There the air is warmed and flows on to the passenger compartment.

6.4. Heat pump

6.4.1. Structure and function of the heat pump

The highly complex system of the heat pump, adapted to the heating and air-conditioning system, places high demands on the workshop personnel during diagnosis, but when it comes to its application the customer is unable to distinguish it from the conventional heating and air-conditioning system in I01 with the range extender.

The heat pump is standard in the BEV vehicles = Battery Electric Vehicle.

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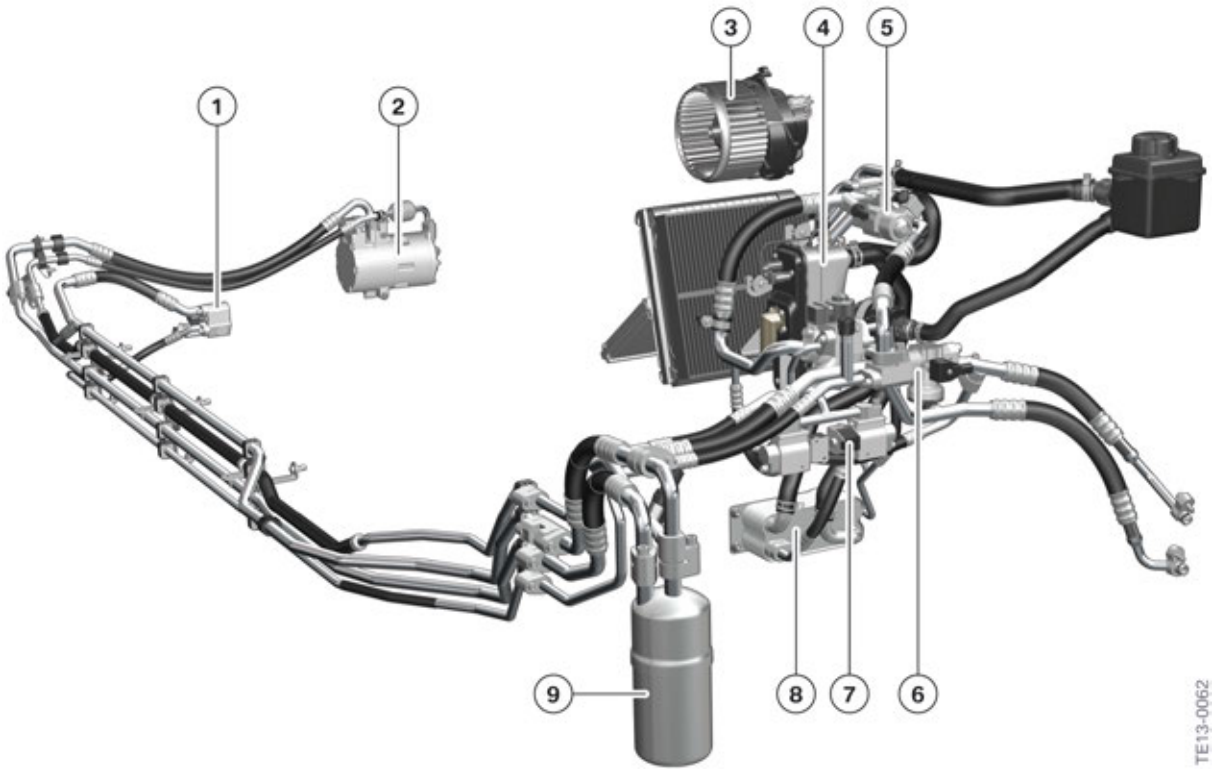

Complete system with heat pump equipment

Index	Explanation
1	Electrical expansion valve (EXV) at the high-voltage battery unit
2	EKK
3	Blower, passenger compartment
4	Electric heating
5	Electrically controlled expansion valve (EXV) for the evaporator in the passenger compartment
6	Refrigerant shutoff valve between condenser and receiver dryer.
7	Refrigerant shutoff valve between EKK and heat pump heat exchanger.
8	Heat pump heat exchanger
9	Receiver dryer

The following table provides an overview of the expansion valves installed.

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6. Components and Systems

Equipment/Expansion valve	Combined expansion and shutoff valve (ETXV) at the high-voltage battery unit and for the evaporator in the passenger compartment	Electrically controlled expansion valve (EXV) at the heat pump heat exchanger, the high-voltage battery unit and for the evaporator in the passenger compartment
Standard equipment IHKA	2 items installed	not installed
BEV I01 with Heat pump	not installed	3 items installed

The BEV I01 with heat pump a fourth refrigerant line together with the three lines from the standard equipment is guided along at the right side sill to the rear end. A heat pump has about 36 other parts (incl. small parts such as brackets, etc.) and about 7 kg of additional weight.

The quantity in the refrigerant circuit with heat pump is 970 g. (2.13 lbs)The quantity of the system with out heat pump is 750 g (1.65 lbs). These quantities are crucial to the operation of the system therefore it is important to always verify the quantity of refrigerant of the system you are working on with the specifications found in ISTA.

The heat pump is responsible for helping increase the range with the same heating and air-conditioning comfort of a system without this device. From an ambient temperature of -10 °C / 14 °F and a mean set-point value of the heating and air-conditioning system (22 °C / 71 °F in automatic function) an interior air temperature control without the additional heating is realized by the electric heating. The heat pump is no longer operated below -10 °C / 14 °F.

The operating mode of the heat pump is specified based on the requirement of the IHKA. The heat pump controller controls the valves and reads in the actual values. However, the central control is in the IHKA control unit.

An evaluation for the diagnosis in the event of a fault is very important for such a complex system. Interruptions, sensor failures, mechanical faults of shutoff valves and electrically controlled expansion valves, can also be diagnosed.

In the event of a fault the system activates the corresponding valve a second time. If the fault is still present, the EKK is switched off until the necessary workshop visit.

The customer does **not** receive any notification thereof, but on hot days will notice that the air-conditioning system is not working. If the high-voltage battery unit becomes too hot due to a lack of cooling, a Check Control message is issued from the powertrain area as soon as the vehicle performance must be restricted in order to not allow the temperature in the high-voltage battery unit to further increase. The customer is requested to visit a workshop by the Check Control message.

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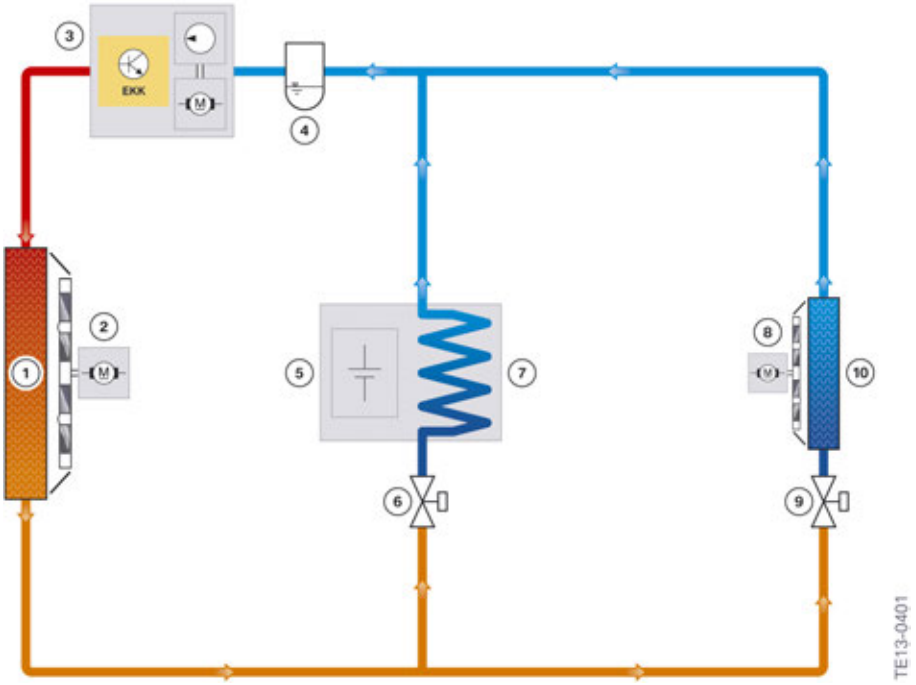
Refrigerant circuit in the I01 with REX



Refrigerant circuit in the I01 with REX

Index	Explanation
1	condenser (with integrated receiver dryer in the I01 with REX)
2	Electric fan
3	EKK
4	Receiver drier (integrated in the condenser in the I01 with REX)
5	High-voltage battery unit
6	Combined expansion and shutoff valve (ETXV) for the cooling loop in the high-voltage battery unit
7	Cooling loops in the high-voltage battery unit
8	Blower for passenger compartment
9	Combined expansion and shutoff valve (ETXV)
10	Evaporator, passenger compartment in the heating and air-conditioning unit

The refrigerant is compressed by the EKK, whereby its pressure and temperature increase. The refrigerant evaporates as a result of the increase in temperature and is reduced into a fluid state again in the condenser (with integrated receiver dryer!!!) when the temperature drops slightly. In the next component of the refrigerant circuit, the expansion valve, the refrigerant is injected into the evaporator in the heating and air-conditioning unit by a defined inflow control and if required also into the cooling loops of the high-voltage battery unit. By injecting a small quantity into the evaporator or the cooling loop the high-pressure refrigerant is released quickly and can absorb heat, i.e. extract heat from the surrounding area. This way it is cooled. The released refrigerant is then guided back to the EKK.

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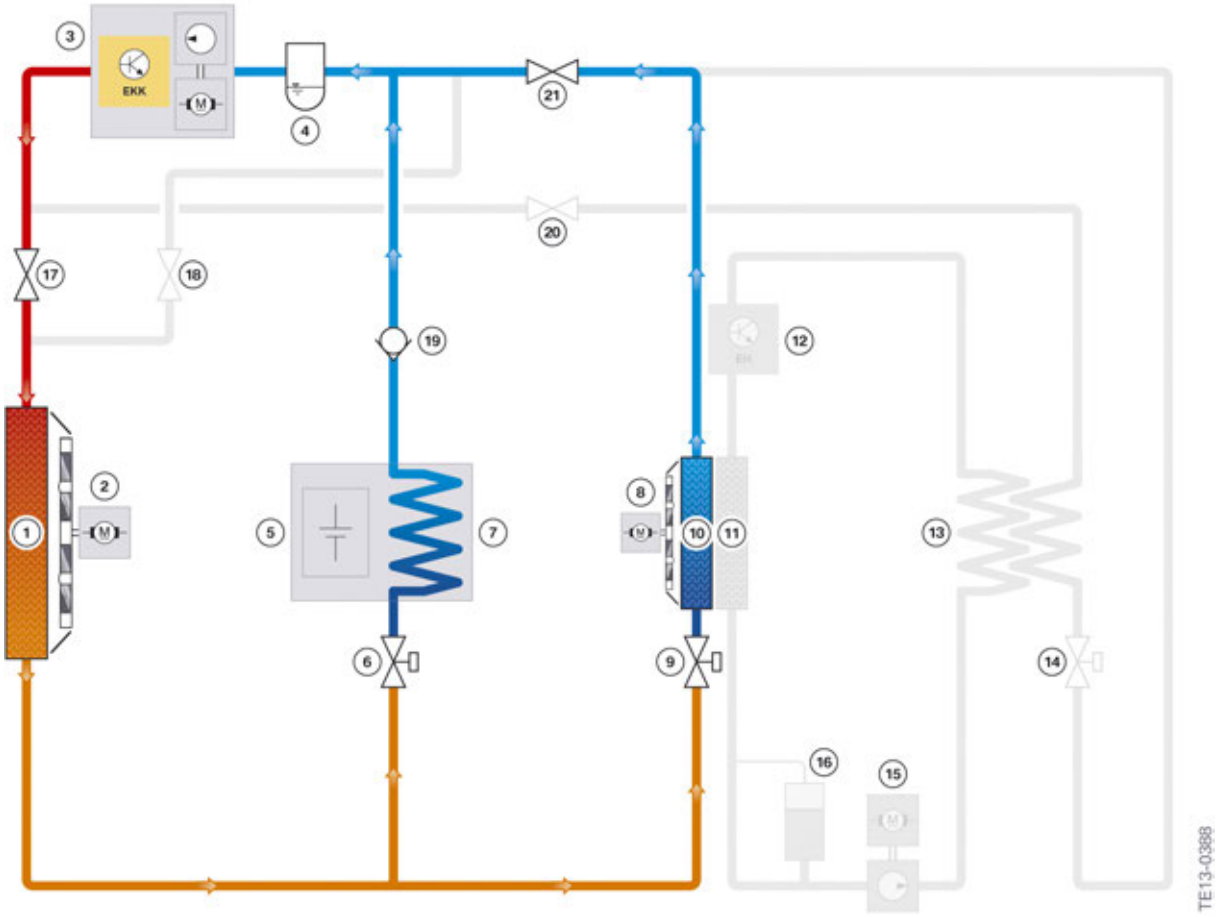
The refrigerant circuit is closed.

Refrigerant circuit with heat pump, I01 with BEV



Refrigerant circuit with heat pump in cooling

Index	Explanation of cooling of heat pump
1	Condenser
2	Electric fan
3	EKK
4	Receiver drier
5	High-voltage battery unit
6	Electrically controlled expansion valve (EXV) for the cooling loop in the high-voltage battery unit
7	Cooling loops in the high-voltage battery unit
8	Blower for passenger compartment
9	Electrically controlled expansion valve (EXV) for the evaporator in the passenger compartment

Index	Explanation of cooling of heat pump
10	Evaporator, passenger compartment in the heating and air-conditioning unit
11	Heat exchanger
12	Electric heating
13	Heat pump heat exchanger
14	Electrically controlled expansion valve (EXV) for the heat pump heat exchanger
15	Electric coolant pump
16	Coolant expansion tank
17	Refrigerant shutoff valve between EKK and condenser. **This valve is spring loaded open!**
18	Refrigerant shutoff valve between condenser and receiver dryer. **This valve is spring loaded closed!**
19	Refrigerant non-return valve
20	Refrigerant shutoff valve between EKK and heat pump heat exchanger. **This valve is spring loaded open!**
21	Refrigerant shutoff valve between electrically controlled expansion valve EXV at the heat pump heat exchanger and the receiver dryer. **This valve is spring loaded open!**

When the heat pump operating mode is not active the refrigerant circuit with this optional equipment is identical to the circuit in the standard equipment. By using the closed refrigerant shutoff valves with the Index numbers 18 and 20 and the open refrigerant shutoff valves with numbers 17 and 21 the circuit is operated completely **normally**.

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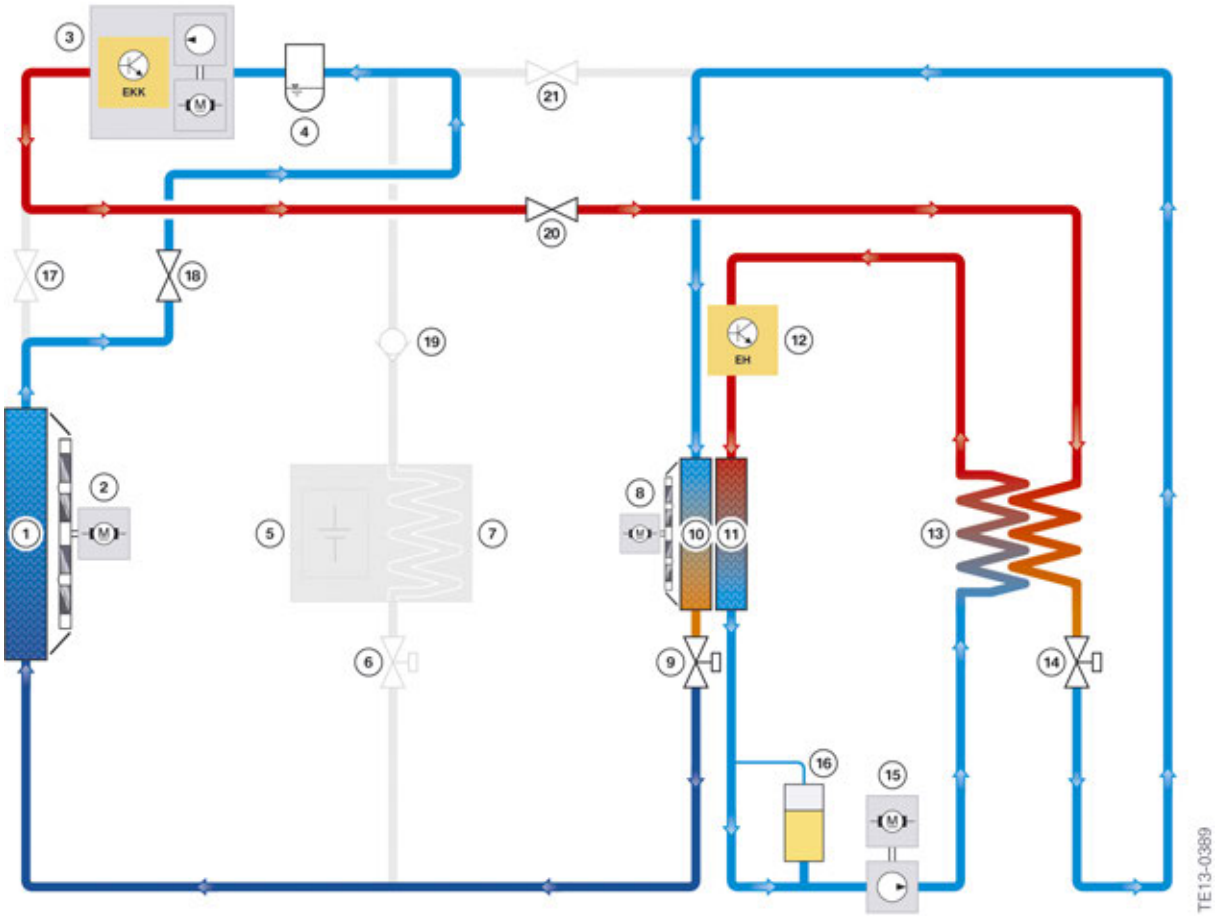
Refrigerant circuit with heat pump, I01 with BEV



Refrigerant circuit with heat pump in heating mode

Index	Explanation of heating mode of heat pump
1	Condenser
2	Electric fan
3	EKK
4	Receiver dryer
5	High-voltage battery unit
6	Electrically controlled expansion valve (EXV) for the cooling loop in the high-voltage battery unit
7	Cooling loops in the high-voltage battery
8	Blower for passenger compartment
9	Electrically controlled expansion valve (EXV) for the evaporator in the passenger compartment
10	Evaporator, passenger compartment in the heating and air-conditioning unit
11	Heat exchanger

Index	Explanation of heating mode of heat pump
12	Electric heating
13	Heat pump heat exchanger
14	Electrically controlled expansion valve (EXV) for the heat pump heat exchanger
15	Electric coolant pump
16	Coolant expansion tank
17	Refrigerant shutoff valve between EKK and condenser. **This valve is spring loaded open!**
18	Refrigerant shutoff valve between condenser and low-pressure battery (receiver dryer). **This valve is spring loaded closed!**
19	Refrigerant non-return valve
20	Refrigerant shutoff valve between EKK and heat pump heat exchanger. **This valve is spring loaded open!**
21	Refrigerant shutoff valve between electrically controlled expansion valve at the heat pump heat exchanger and the low-pressure accumulator (receiver dryer). **This valve is spring loaded open!**

If the heat pump is used in heating mode, the refrigerant shutoff valves with the numbers 17 and 21 are closed and those with numbers 18 and 20 are open. As a result, there is a diversion of the refrigerant circuit through the heat pump heat exchanger.

The heat is therefore no longer emitted unused at the condenser, but is emitted at the coolant for the heater circuit. An electrically controlled expansion valve (EXV) at the output of the heat pump heat exchanger builds up the pressure so that enough heat can develop here. In order to close the circuit again, the evaporator in the heating and air-conditioning unit is also used by the electrically controlled expansion valve (EXV) for building up the refrigerant pressure. The actual electrically controlled expansion valve (EXV) installed for cooling is activated so that the pressure of the refrigerant in the evaporator can be increased again and the arising heat can also be used. Then the released refrigerant is directed back through the condenser in the reverse direction via the open refrigerant shutoff valve 18 and the receiver dryer to the EKK.

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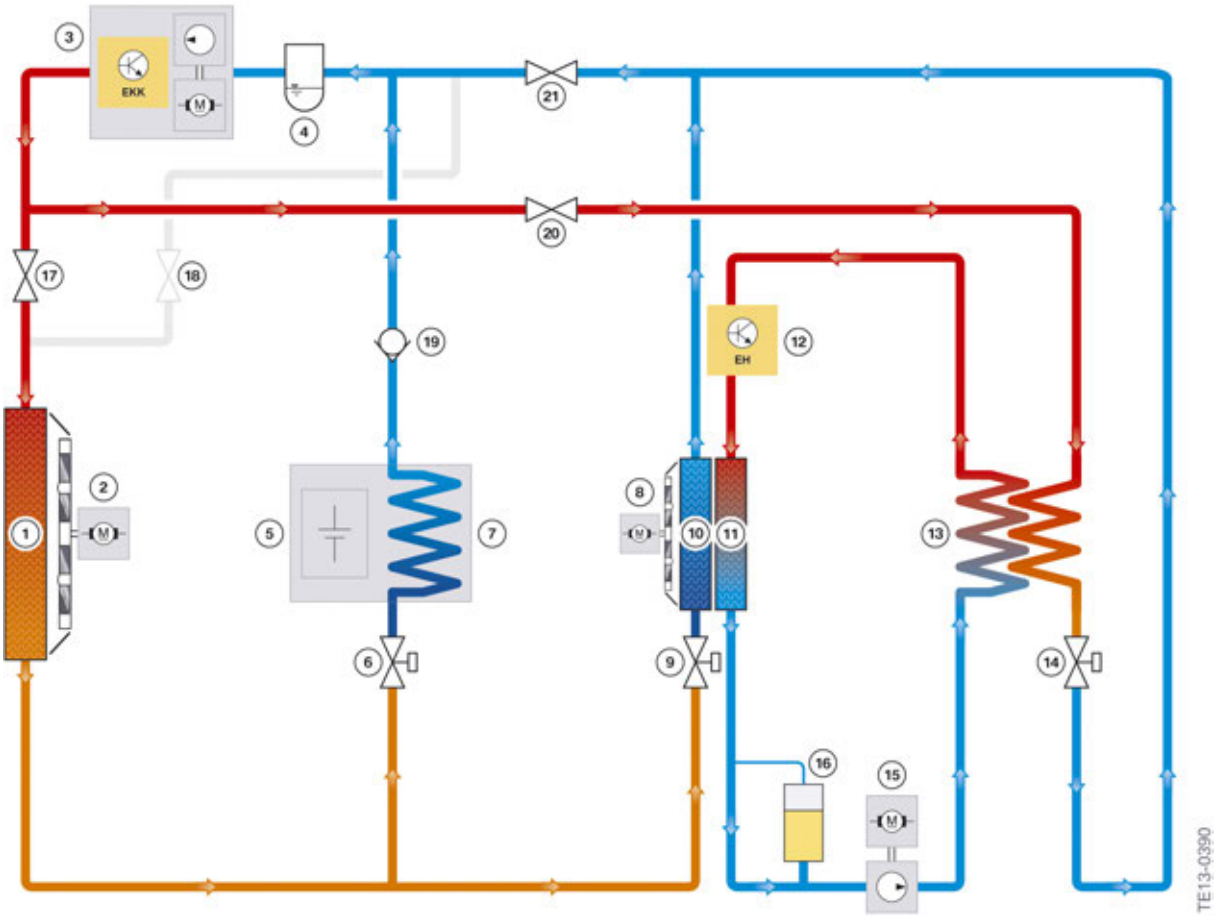
Refrigerant circuit with heat pump, in mixed operation, I01 with BEV



Refrigerant circuit with heat pump in mixed operation

Index	Explanation of mixed operation of heat pump
1	condenser
2	Electric fan
3	EKK
4	receiver dryer
5	High-voltage battery unit
6	Electrically controlled expansion valve (EXV) for the cooling loop in the high-voltage battery unit
7	Cooling loop in the high-voltage battery unit
8	Blower for passenger compartment
9	Electrically controlled expansion valve (EXV) for the evaporator in the passenger compartment
10	Evaporator, passenger compartment in the heating and air-conditioning unit
11	Heat exchanger

Index	Explanation of mixed operation of heat pump
12	Electric heating
13	Heat pump heat exchanger
14	Electrically controlled expansion valve (EXV) for the heat pump heat exchanger
15	Electric coolant pump
16	Coolant expansion tank
17	Refrigerant shutoff valve between EKK and condenser. **This valve is spring loaded open!**
18	Refrigerant shutoff valve between condenser and receiver dryer. **This valve is spring loaded closed!**
19	Refrigerant non-return valve in the pressure line from the cooling loop in the high-voltage battery unit to the receiver dryer
20	Refrigerant shutoff valve between EKK and heat pump heat exchanger. **This valve is spring loaded open!**
21	Refrigerant shutoff valve between electrically controlled expansion valve (EXV) at the heat pump heat exchanger and the receiver dryer. **This valve is spring loaded open!**

If the heat pump is used in the mixed operation, the shutoff valves with the numbers 17, 20 and 21 are open. The shutoff valve with the number 18 is closed as there should be no reverse flow. This results in a division of the hot, high-pressure refrigerant.

On the one hand, cooling of the high-voltage battery unit and dehumidification of the passenger compartment can be realized by the cooling at the evaporator, on the other hand, the divided heat transported with the refrigerant is used for the heat pump heat exchanger.

Another advantage in comparison to a vehicle without a heat pump is that in the event of strong sunlight, and hence the necessary blowing of cold air from the ventilation grille is also not necessarily an advantage for the footwell. The vehicle without a heat pump must be slightly heated using the electric heating in order to acclimatize the footwell to a pleasant temperature. In mixed operation with a heat pump the footwell can therefore be heated without using energy using the heat pump heat exchanger.

6.4.2. Components of the heat pump

The following wiring diagram provides an overview of the control units installed and their connection.

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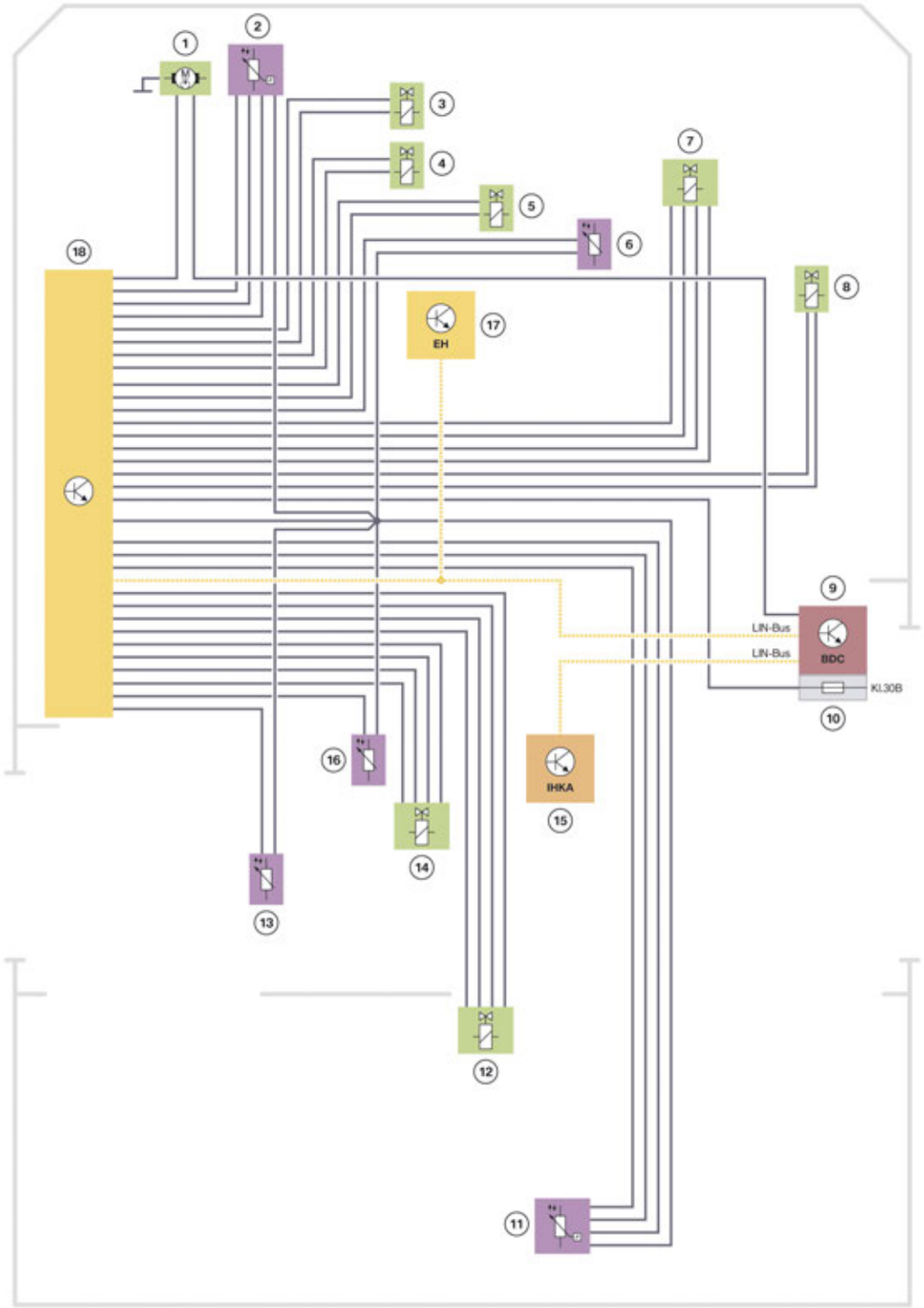

Wiring diagram with heat pump system

The connection of the heat pump controller via the local interconnect network (LIN) bus at the Body Domain Controller (visible in the wiring diagram). It is important to note that the signal is only looped through the BDC.

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Index	Explanation
1	Electric coolant pump
2	Refrigerant pressure-temperature sensor
3	Refrigerant shutoff valve between EKK and condenser
4	Refrigerant shutoff valve between condenser and receiver dryer. **This valve is spring loaded closed!**
5	Refrigerant shutoff valve between EKK and heat pump heat exchanger. **This valve is spring loaded open!**
6	Refrigerant temperature sensor
7	Electrically controlled expansion valve (EXV) for the evaporator in the passenger compartment
8	Refrigerant shutoff valve between electrically controlled expansion valve (EXV) at the heat pump heat exchanger and the receiver dryer. **This valve is spring loaded open!**
9	Body Domain Controller (BDC)
10	Fuse, terminal 30B
11	Refrigerant pressure-temperature sensor
12	Electrically controlled expansion valve (EXV) for the cooling loop in the high-voltage battery unit
13	Refrigerant temperature sensor
14	Electrically controlled expansion valve (EXV) for the heat pump heat exchanger
15	IHKA control unit
16	Refrigerant temperature sensor
17	Electric heating
18	Heat pump controller

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Heat pump controller

Installation location of heat pump controller, BEV only

The local interconnect network bus serves as a data line for the communication between the heat pump controller and the IHKA control unit.

The control of the actuators such as the refrigerant shutoff valves and the electrically controlled expansion valves (EXV), as well as the evaluation of the sensor system (refrigerant temperature sensors and refrigerant pressure-temperature sensors), is processed by the heat pump controller on the analog route.

The heat pump controller is responsible for the conversion of analog signals to digital signals and vice versa.

The coolant pump, as the only component of the heating and air-conditioning system, is supplied with voltage from the Body Domain Controller. However, the control is effected via the heat pump controller in the form of a pulse-width modulated signal.

The central control is assumed by the IHKA control unit connected via the local interconnect network bus. The heat pump controller only implements its commands and makes available the sensor values.

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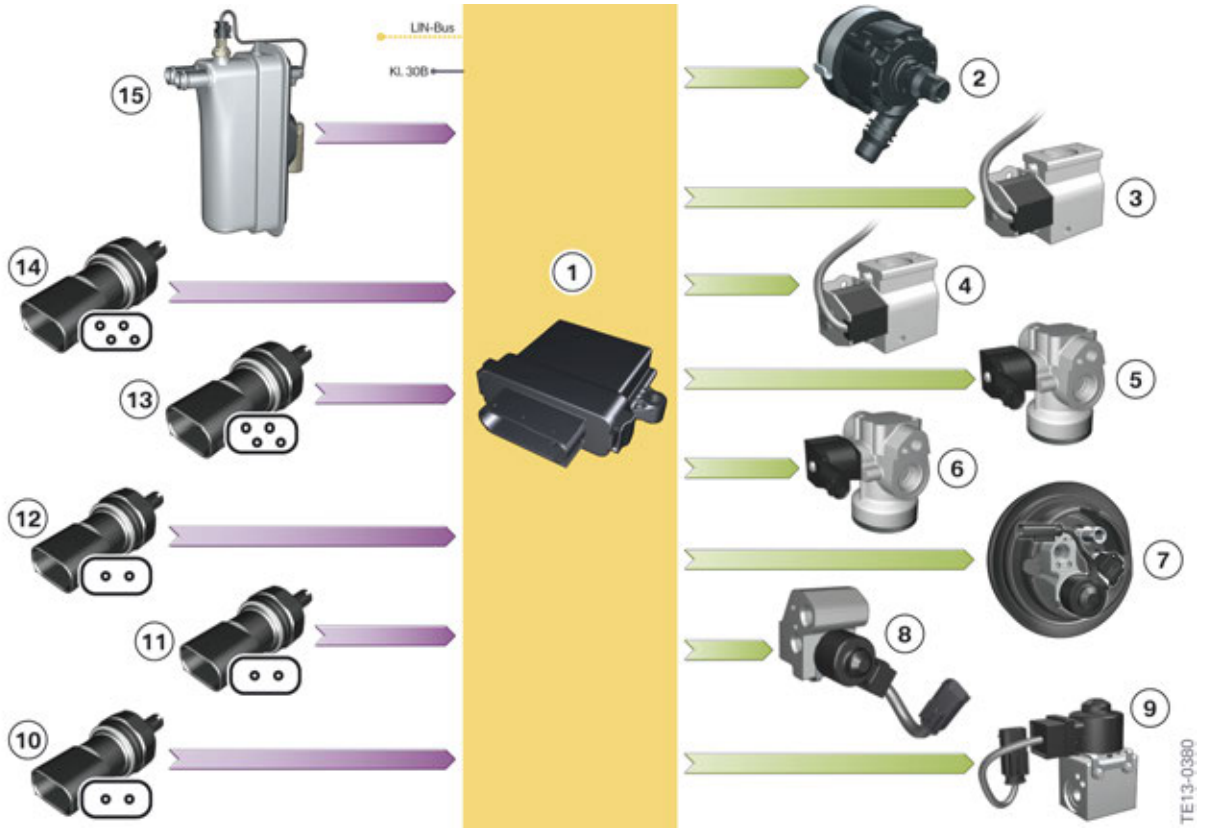
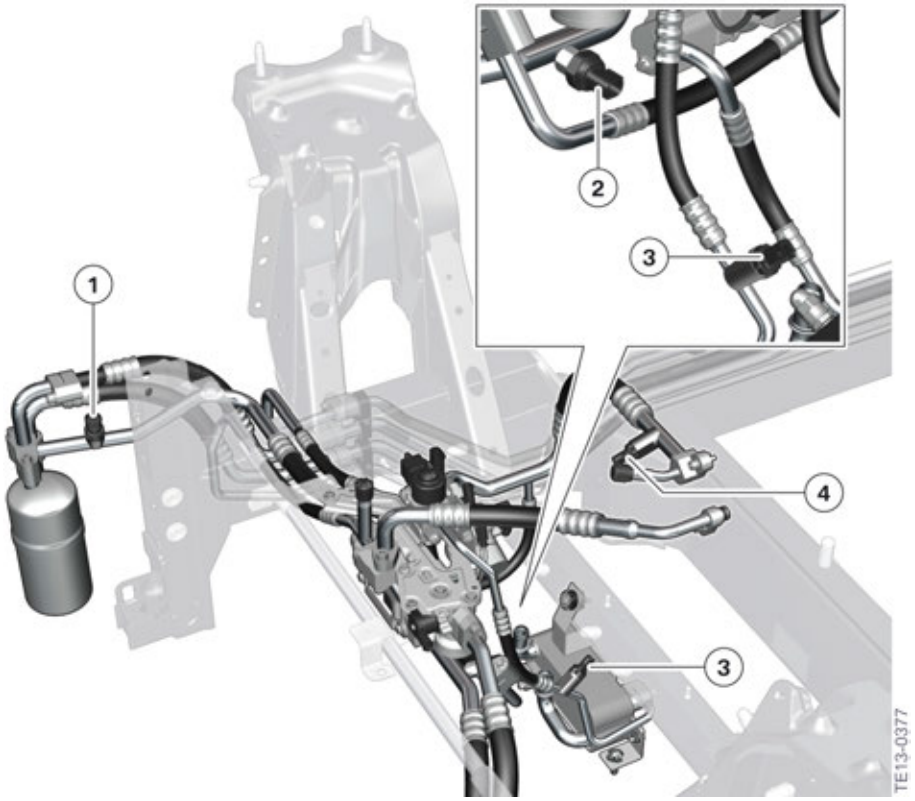


Sensors and actuators of the heat pump controller

Index	Explanation
1	Heat pump controller
2	Electric coolant pump (12 V)
3	Refrigerant shutoff valve between EKK and condenser
4	Refrigerant shutoff valve between EKK and heat pump heat exchanger
5	Refrigerant shutoff valve between condenser and receiver dryer
6	Refrigerant shutoff valve between electrically controlled expansion valve (EXV) for the heat pump heat exchanger and the receiver dryer
7	Electrically controlled expansion valve (EXV) for the evaporator in the passenger compartment
8	Electrically controlled expansion valve (EXV) for the cooling loop in the high-voltage battery unit
9	Electrically controlled expansion valve (EXV) for the heat pump heat exchanger
10	Refrigerant temperature sensor 1
11	Refrigerant temperature sensor 2

Index	Explanation
12	Refrigerant temperature sensor 3
13	Refrigerant pressure-temperature sensor 1
14	Refrigerant pressure-temperature sensor 2
15	Electric heating



Installation location of the refrigerant pressure-temperature sensors in the front area with the heat pump

Index	Explanation
1	Refrigerant pressure-temperature sensor 1 with heat pump
2	Refrigerant pressure sensor for switching off in the event of excess pressure in the refrigerant circuit (is available with and without a heat pump)
3	Refrigerant temperature sensor 1 with heat pump
4	Refrigerant temperature sensor 3 with heat pump

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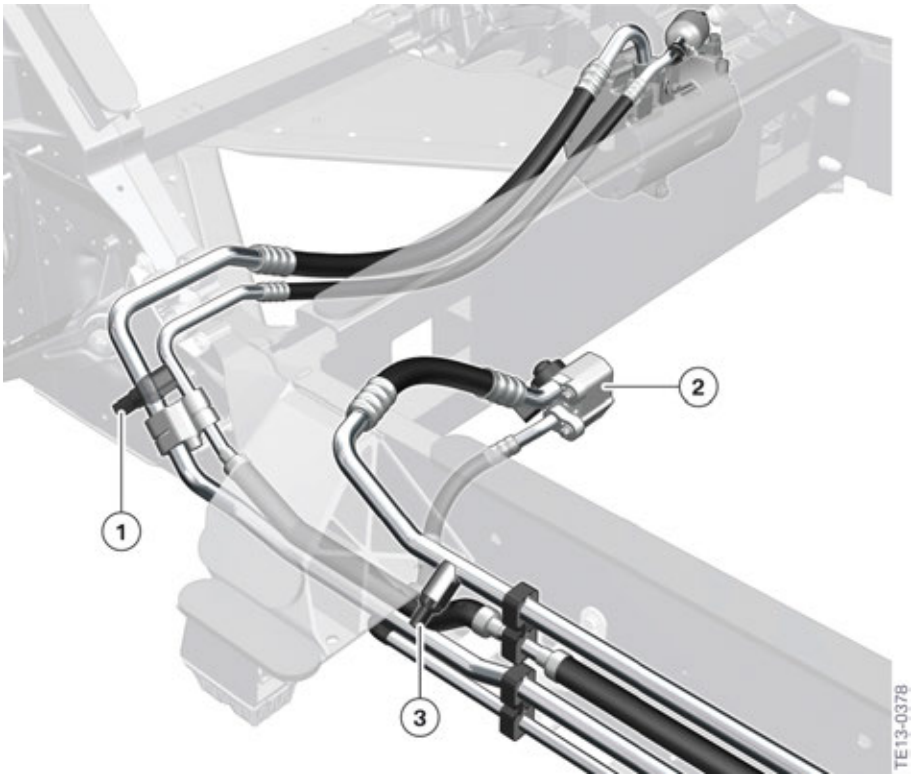


Installation location of the refrigerant pressure-temperature sensors in the rear area of the vehicle with heat pump

Index	Explanation
1	Refrigerant pressure-temperature sensor 2
2	Electrically controlled expansion valve (EXV) for the cooling loop in the high-voltage battery unit
3	Refrigerant temperature sensor 2

Refrigerant temperature sensors

There are three temperature sensors in the refrigerant circuit, which transmit their values to the heat pump controller for evaluation.

Refrigerant pressure-temperature sensors

In addition to the three refrigerant temperature sensors, two refrigerant pressure-temperature sensors are also installed in the refrigerant circuit of the heat pump. They transmit their values to the heat pump controller for evaluation.

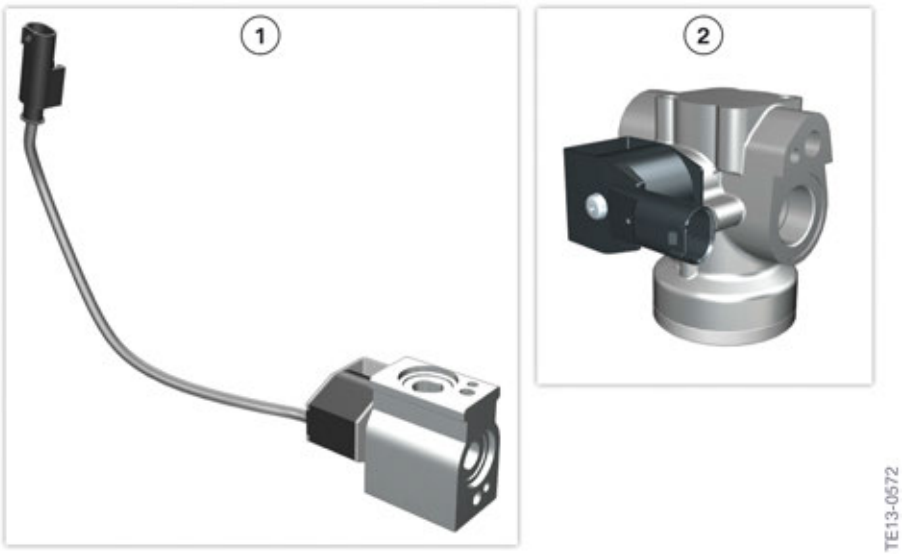
If a sensor has to be replaced due to a fault, after drawing off the refrigerant ensure that the screw thread is held using a suitable tool when removing. This way damage to the refrigerant line is avoided. The replacement of a faulty refrigerant line involves timely and costly repair work.

Refrigerant shutoff valve

There are a total of four refrigerant shutoff valves. The individual shutoff valves control the refrigerant circuit and can cause a different direction of flow for the refrigerant condenser and the evaporator with their switching. The different operating modes of the heat pump such as cooling, heating mode and mixed operation can therefore be implemented. It is not possible to reverse the direction of the refrigerant circuit of the EKK and the receiver dryer due to the lubrication and compression via the air conditioning compressor. The refrigerant **always** flows through these two components in the same direction of flow.

The refrigerant shutoff valves are open or closed by the heat pump controller, according to the messages sent by the IHKA. The shutoff valves are only controlled as fully open or closed, whereby three of the four shutoff valves are spring loaded open without current and one is spring loaded closed without current. The closed refrigerant shutoff valve is open during heating mode of the heat pump and allows the return flow of the refrigerant from the condenser via the receiver dryer to the EKK.

The refrigerant shutoff valves are all located in the front area of the vehicle and are available in the two versions mentioned below.



Refrigerant shutoff valves

Refrigerant shutoff valve in graphic 1	Refrigerant shutoff valve in graphic 2
Two installed refrigerant shutoff valves in the design shown in graphic 1. One from the EKK to the heat pump heat exchanger, the other from the EKK to the condenser.	Two installed refrigerant shutoff valves in the design shown in graphic 2. One from the evaporator to the receiver dryer, the other from the condenser to the receiver dryer. It is spring loaded closed without current.

Electrically controlled expansion valve (EXV)

With the heat pump, the thermally controlled expansion valve (TXV), as well as the combined expansion and shutoff valve (ETXV) for the cooling loop in the high-voltage battery unit, are replaced for three electrically controlled expansion valves (EXV). These valves have no thermal control, they control the refrigerant circuit infinitely from 0 to 100 % with their stepper motor.

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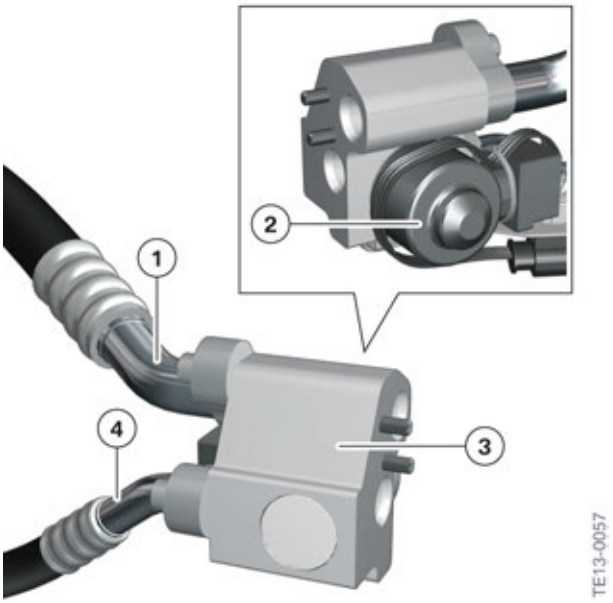
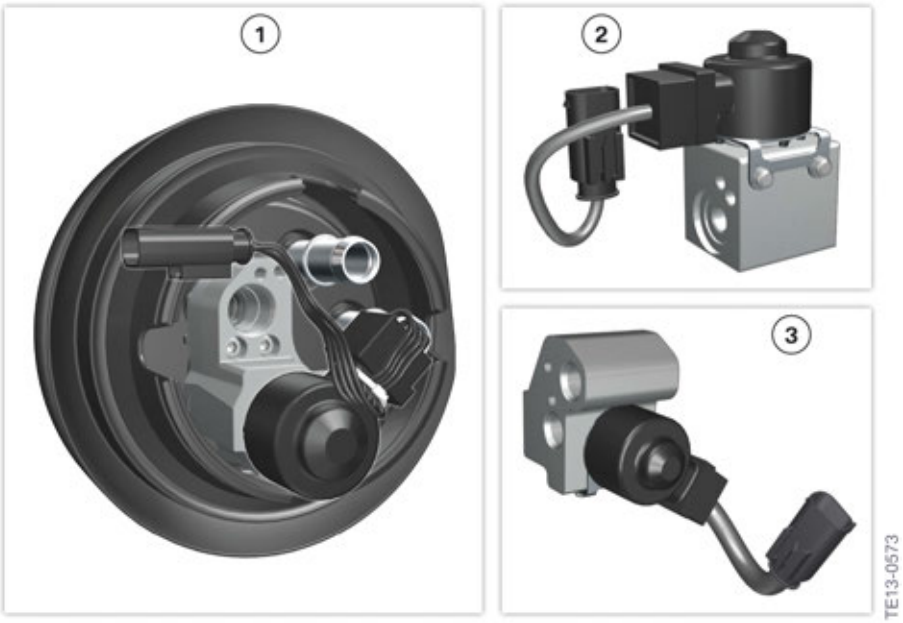
The electrically controlled expansion valves (EXV) are subject to calibration after every 20th engagement of the parking lock in order to adjust the accuracy of the activation and guarantee exact control of the valves. The activation is generally effected roughly three minutes after the vehicle has stopped.



Electrically controlled expansion valve (EXV)

Index	Explanation
1	Low pressure line, refrigerant
2	Stepper motor, infinite control from 0 to 100 % (activation by the heat pump controller)
3	Housing of electrically controlled expansion valve (EXV)
4	High pressure line, refrigerant



Different versions of the electrically controlled expansion valves (EXV)

Index	Explanation
1	Electrically controlled expansion valve (EXV) at the bulkhead for the evaporator in the passenger compartment
2	Electrically controlled expansion valve (EXV) in the front area of the vehicle for the heat pump heat exchanger
3	Electrically controlled expansion valve (EXV) in the rear Drive module for the cooling loop in the high-voltage battery unit

receiver dryer

The receiver dryer with the heat pump, satisfies the function of the intake plenum and moves the refrigerant circuit through the refrigerant oil with the necessary lubrication. It serves as a storage volume in order to be able to offset the refrigerant which decreases slowly over time and to guarantee operation of the heat pump circuit.

In a vehicle with a heat pump the receiver dryer is bigger as the volume of the refrigerant circuit here is larger, requiring an increased offset range. The receiver dryer is located in the front right area below the front light assembly. In a I01 REX vehicle that has a condenser with integrated receiver dryer cannot be replaced individually. It must be replaced together with the condenser.

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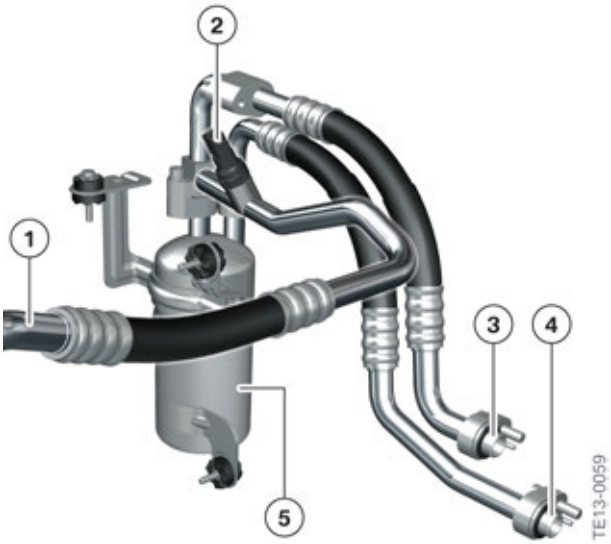

receiver dryer I01 BEV only

Index	Explanation
1	Low pressure line to the refrigerant shutoff valve 3
2	Refrigerant pressure-temperature sensor 1
3	Intake pipe for the electrically controlled expansion valve (EXV) for the cooling loop in the high-voltage battery unit
4	Intake pipe for the EKK
5	receiver dryer

Heat pump heat exchanger

The heat pump heat exchanger uses the heat from the hot, high-pressure refrigerant and forwards it to the heater circuit via the flowing coolant.

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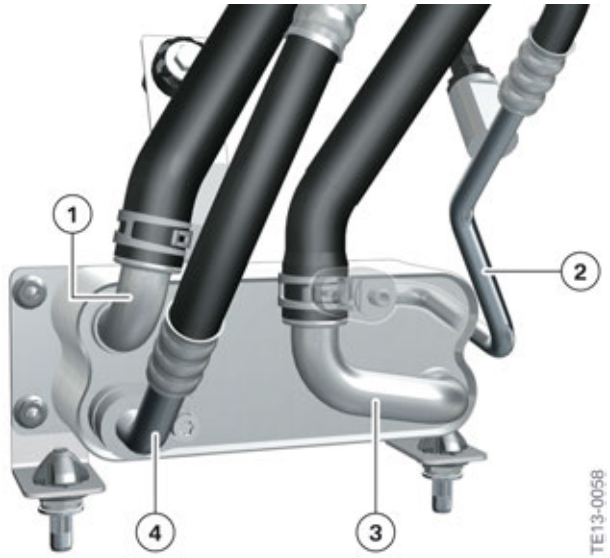

Heat pump heat exchanger

Index	Explanation
1	Coolant connection for the electric heating
2	Refrigerant pressure line via the electrically controlled expansion valve (EXV) with specific adjustment either to the evaporator or the receiver dryer
3	Coolant connection of the electric coolant pump
4	Refrigerant pressure line from the EKK via the refrigerant shutoff valve 2

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7. Service Information

There is no maintenance for the refrigerant circuit.

The corresponding warnings must be adapted to the use of the refrigerant.

Work on heating and air-conditioning systems must only be performed by competent and qualified personnel.

7.1. Maintenance of refrigerant circuit/heating system

The coolant in the heater circuit must be replaced according to the specified service intervals.

Attention must be paid that the correct coolant with the designation "Coolant concentrate i3" is used, as has already been described in this technical training manual.

7.2. Replacing the microfilter

Special attention must be paid to the replacement of the **two** microfilters. If the upper filter was removed for the replacement, then the lower filter must also be replaced.

The lower microfilter is barely visible and must be pulled upwards in order to be replaced.

Heating and air-conditioning unit with microfilter pulled out

7.3. Diagnosis and maintenance with ISTA

In the Integrated Service Technical Application ISTA the diagnosis and activation of the sensors, actuators and components can be performed using procedures.

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7. Service Information

Upon connection to an A/C service station all refrigerant shutoff valves and expansion valves have to be opened with an electric control in order to be able to evacuate or fill the entire refrigerant circuit. This is done by following the procedure in ISTA.

Further service functions are integrated in the procedures and are not yet identified at the time of the creation of this technical training manual.

7.4. A/C service station

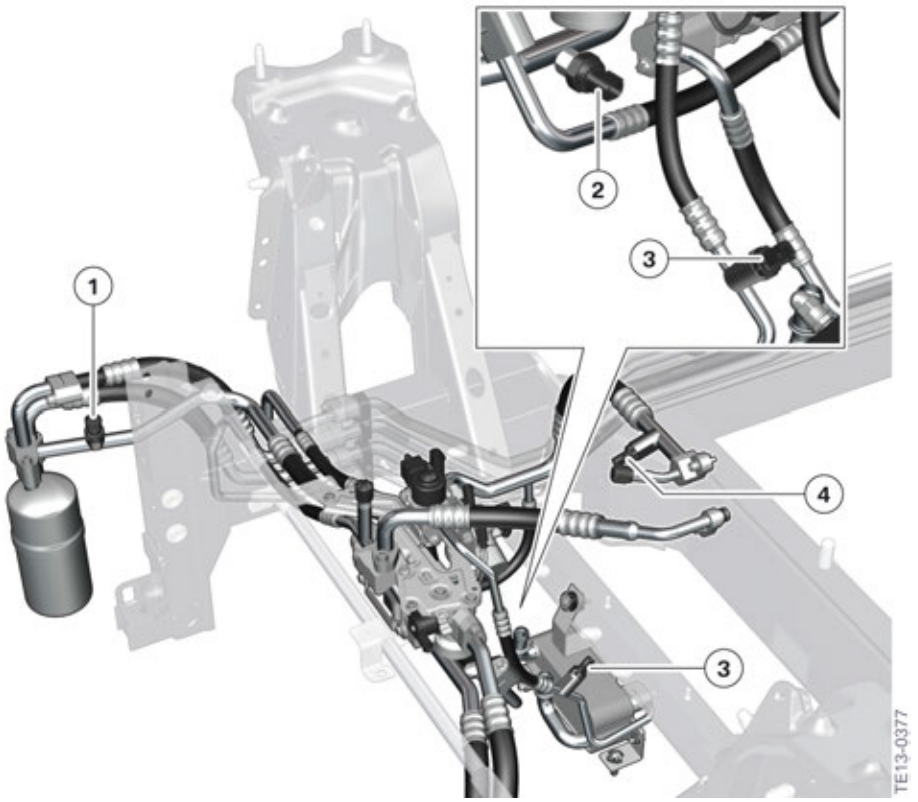
A/C service station (European model shown)

The refrigerant filling of R134a is identified with black screw caps on the filling valves. The current A/C service stations are still used for the I01.

Since the I01 BEV version is equipped with a heat pump, the diagnostic program must be started via ISTA before commencement of the evacuation with the A/C service station in order to open the electrically controlled expansion valves and the refrigerant shutoff valves

of the refrigerant circuit. This procedure must also be observed for a vehicle in the standard equipment. However, only the combined expansion and shutoff valves have to be opened here.

If access is not possible via the diagnostic program, then as an emergency solution the refrigerant temperature sensor 3 (see Index 4) in the refrigerant circuit is removed when terminal 15 is switched on in order to cause the opening of all refrigerant shutoff valves and electrically controlled expansion valves EXV. Terminal 15 must also remain switched on after the sensor plug is removed in order to maintain the function. This procedure is **only** possible for vehicles equipped with the heat pump.



Installation location of refrigerant temperature sensor 3

Index	Explanation
1	Refrigerant pressure-temperature sensor 1 with heat pump
2	Refrigerant pressure sensor for switching off in the event of excess pressure in the refrigerant circuit is available for all equipment specifications
3	Refrigerant temperature sensor 1 with heat pump
4	Refrigerant temperature sensor 3 with heat pump

Other work with the A/C service station is still being examined and was not yet definitive at the time of the creation of this product information bulletin. Please obtain current information from the repair instructions on the I01.

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